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May 9, 1936

# ANNUAL INVESTIGATIVE REPORT

## INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION

## 1935 - 1936

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EXPERIMENT STATION
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# ANNUAL INVESTIGATIVE REPORT

## 1935 - 1936

## INTRODUCTION

During the past year significant progress was made in all phases of erosion-streamflow, forest management, and range management research by the Intermountain Forest and Range Experiment Station. Through the continued availability of emergency funds and effective cooperation by the regional administrative organization, current and back data to a large extent were compiled and analyzed, the facilities for research were improved, and work on many new aspects of going projects was initiated. As a result of these efforts, much valuable information bearing on the major problems encountered in the administration of the national forests of this region was obtained.

The current results of studies made by the station during the past year and plans for work in 1936 were presented for consideration at the annual investigative committee meeting in the Regional Office at Ogden, Utah, on March 18, 1936. All in attendance at the meeting, which included most of the regional office staff and a large percentage of supervisors and their principal assistants, showed keen interest in the data presented and offered many helpful suggestions for advancing the research program.

Special attention at this meeting was focused on the need for information concerning the lodgepole pine type, the general feeling of the group being that silvicultural investigations by the station should be expanded at once to include this new field of study. The general thought was expressed, also, that all going projects should be continued and expanded to include work on a number of special problems. In this connection, groups convened after the general meeting to work out ways and means of incorporating the suggested phases of new work into the station program. From these special meetings, cooperative arrangements were perfected between the station and the administrative staff for refining and expanding fire studies, for proceeding with intensive studies of erosion control methods, and for establishing trial stations for artificial reseeding purposes.

This report contains a summary of the results obtained from research during the past year and outlines for work planned for 1936, approximately as this information was presented at the investigative meeting. Supplementary statements are also included concerning the status of publications, proposals for new work and natural areas, the situation regarding work centers, maintenance needs, and project summaries. The first part of this report has been prepared with a view toward rather wide circulation, whereas the supplementary statements are for more limited distribution.

## STATION ORGANIZATION 1935-1936

### ADMINISTRATIVE & CLERICAL

| | | |
|---|---|---|
| Permanent | Reed W. Bailey . . . . . | Director |
| | Walter E. Mann . . . . . | Adm. Assistant |
| | Marguerite A. Israelson . . | Clerk |
| | Herbert Burrell . . . . . | Clerk |
| | Leona H. O'Donnell . . . . . | Asst. Clerk |
| Emergency | Willard M. Chase . . . . . | Asst. Clerk |
| | Zura Gerdicia . . . . . | Jr. Steno. |
| | Byron F. Thurmond . . . . . | Prin. Engr., Draftsman |
| | Lowell Woodward . . . . . | Jr. Range Examiner |

### FOREST MANAGEMENT (Silvical Research)

| | | |
|---|---|---|
| Permanent | C. A. Connaughton . . . . . | Silviculturist |
| | E. L. Mowat . . . . . | Asst. Silviculturist |
| Emergency | Lewis Clark . . . . . | Jr. Forester |
| | A. R. McConkie . . . . . | Jr. Forester |
| | Wayne B. Read . . . . . | Jr. Forester |

### RANGE MANAGEMENT INVESTIGATIONS

DESERT SHRUB

| | | |
|---|---|---|
| Regular | Dr. George Stewart . . . . . | Sr. For. Ecologist |
| | Selar S. Hutchings . . . . . | Asst. Range Examiner |
| Emergency | Ira Clark . . . . . | Jr. Range Examiner |
| | James L. Jacobs . . . . . | Jr. Range Examiner |
| | Harold W. Norton . . . . . | Jr. Range Examiner |
| | Ben. R. Stahmann . . . . . | Jr. Range Examiner |

SAGEBRUSH-WHEATGRASS RANGE

| | | |
|---|---|---|
| Regular | Dr. George Stewart . . . . . | Sr. For. Ecologist |
| | G. D. Pickford . . . . . | For. Ecologist |
| | J. F. Pechanec . . . . . | Jr. Range Examiner |
| Emergency | Lloyd A. Hague . . . . . | Jr. Range Examiner |
| | A. R. Murdock . . . . . | Asst. Tech. |
| | S. D. Warner . . . . . | Jr. Range Examiner |

RANGE MANAGEMENT INVESTIGATIONS (cont.)

SUMMER RANGE - WASATCH PLATEAU

| | | |
|---|---|---|
| Regular | Dr. George Stewart | Sr. For. Ecologist |
| | Raymond Price | Asso. Range Examiner |
| Emergency | Leslie R. Albee | Jr. Range Examiner |
| | James M. Hockaday | Jr. Range Examiner |
| | Dr. E. C. McCarty | Asso. Conservationist |
| | Dr. Sylvia M. Griswold | Jr. For. Ecologist |

ARTIFICIAL RESEEDING

| | | |
|---|---|---|
| Regular | Dr. George Stewart | Sr. For. Ecologist |
| | Dr. R. H. Walker | Conservationist |
| Emergency | Alvin C. Hull | Jr. Range Examiner |

EROSION-STREAMFLOW INVESTIGATIONS

GREAT BASIN (UTAH) EROSION

| | | |
|---|---|---|
| Regular | George W. Craddock | Sr. Range Examiner |
| | A. R. Croft | Asso. Conservationist |
| Emergency | Leland K. Hill | Jr. Civil Engr. |
| | Howard R. Foulger | Asst. Tech. |
| | J. Wallace Owen | Asst. Conservationist |
| | Howard E. Peterson | Jr. Range Examiner |
| | George A. Tribbey | Jr. Civil Engr. |

BOISE (GRANITIC SOILS) EROSION

| | | |
|---|---|---|
| Regular | George W. Craddock | Sr. Range Examiner |
| | C. K. Pearse | Asso. Range Examiner |
| Emergency | Kenneth M. Daniels | Jr. Range Examiner |
| | Maurice W. March | Asst. Tech. |
| | Samuel B. Woolley | Asst. Tech. |

## EROSION AND STREAMFLOW INVESTIGATIONS

Erosion streamflow investigations during the past year involved a continuation and expansion of studies concerning the problems of water supply, floods and soil conservation. Work centered on the steep slopes of the Wasatch front at the Wasatch Branch Station and the summer range of the Wasatch Plateau at the Great Basin Branch Station in Utah, and on the granitic soils of the Boise River watershed at the Boise Basin Branch Station in Idaho. The current results of studies on the major watershed problems in Utah and Idaho and the plans for further work in 1936 are summarized in the following sections:

### UTAH EROSION

Limited water supplies and the menace of floods and accelerated erosion constitute two of the most serious problems affecting the security of the people in the Great Basin province and upon which influence studies were concentrated in Utah.

### Water Yield Studies

#### 1. The Water Supply Problem in Utah

Every city, town, and community of any consequence in the Great Basin, exclusive of a few mining towns, is located in a semidesert valley at the mouth of a perennial stream that has its source on an adjacent or nearly watershed and from which water is diverted for domestic, agricultural and industrial purposes. The importance of water from the high mountains of Utah, a typical basin State, is revealed by the following facts brought out in an economic study that was made during the past year:

a. Approximately 80 percent of the water used in Utah is derived from about 10,400,000 acres of range watershed lands above 7,000 feet elevation, most of which are under Forest Service administration. The annual yield of water from this source is about 3,200,000 acre-feet valued at about $10,000,000.

b. About 1-1/3 billion dollars have been invested in developments in the semidesert valleys of the State, most of which directly or indirectly are dependent upon adequate supplies of water. This sum not only represents more than $2,500 per capita, but it is also equivalent to an investment of about $129 in each of the 10,400,000 acres of watershed lands from which most of the water is derived for maintaining the valley developments.

c. The value of streamflow is further illustrated by the fact that approximately one-half of all primary wealth production in Utah -- about $48,000,000 -- is from agriculture and livestock, both of which are directly dependent on streamflow water supply.

d. The extremely high value that is placed on small stream water in this region is illustrated by the situation in Davis County, Utah. Here five small drainages having a total area of only 8,557 acres with 5,360 acres in the water yielding zone above 7,000 feet elevation yields water with a book value of $210,000 which is about $39 for each acre above this elevation.

e. Hydroelectric plants are the principal source of electrical energy in Utah. About 99 percent of such energy generated in the State is produced by plants worth about $20,000,000 located at the base of steep mountains or on streams that have their permanent source of supply in high watersheds. The value of power generated by this source of energy is between $4,000,000 and $6,000,000 annually calculated at .013 per kilowatt hour at the place of generation.

f. Consultants of the State Planning Board estimate that approximately $100,000,000 in new industrial enterprises for which raw materials are available may never materialize due to lack of water, and economists point out that a definite downward trend in the rate of population increase is closely related to the limitation of water for agricultural, industrial, and even domestic purposes.

g. In the State of Utah there has been invested about $40,000,000 in irrigation enterprises largely based on mountain streamflow, but the State is fast reaching the limit of this source of supply. The extent to which efforts are made to supplement the low summer flow of these western streams is indicated by a recent project in the vicinity of Ogden. Here $2,500,000 is being spent on water development structures to provide supplementary water for about 13,000 acres of developed land at a cost of $108 per acre and to provide about 3 acre-feet of water per acre for 2,500 acres of new land at a cost of $225 per acre. The cost of this project is an investment of about $56 for each of the 48,000 acres of water yielding area on the watershed. To overcome in part this acute water situation recent proposals include the diking of Great Salt Lake to create a small fresh water lake at a cost of $16,000,000 and transmountain diversion from the Green River drainage at a cost of about $90,000,000.

These data lead to the conclusion that the State of Utah generally is approaching the point where water may completely check further development. These data also suggest that in order to safeguard the huge investments already made, it is highly essential that proper cover conditions be maintained on the watershed lands so as to insure the maximum yields of usable water. Since a large percentage of the watershed lands are within national forests, the administration and coordination of the uses of resources on these lands constitute a great responsibility which amply justifies research aimed at determining the management requirements for watershed protection purposes.

A paper on the importance of watershed lands in Utah is nearing completion for publication in the Geographical Review.

2. Farmington Experimental Watersheds

The determination of plant cover influences on water yield from steep watersheds typical of the Wasatch Forest was initiated during the past year on a series of eight experimental tributaries of Farmington Canyon near the Wasatch Branch Station. With CCC and ERA help the following progress was made on this installation:

a. A detailed topographic map of Farmington Canyon was completed.

b. A road was extended partly into the experimental tributaries, supplemented by trails for accessibility purposes.

c. Cut-off walls and gaging instruments were installed on four of the watersheds.

d. Rain gages to measure precipitation generally over the watersheds and instruments for one physical factor station have been purchased for installation in 1936.

e. Plans have been outlined for completing the construction phases of the installations and for obtaining a detailed plant and soil inventory of the watersheds.

The watersheds selected for this study range in size from about 35 to 126 acres. All have perennial streams and suitable gaging sites and are generally similar with respect to geology, slope, aspect, soil and plant cover. Moreover, they contribute water to one of the most intensively developed agricultural sections in Utah and because of their potential accessibility are of high demonstrational value.

3. Model Flume Studies

A combination Venturi flume and trapezoidal weir equipped with a trash rack and an open channel float appears to be best adapted for stream gaging installations on experimental watersheds in this region, according to model flume studies recently completed in the hydraulics laboratory of the Utah State Agricultural College at Logan. This combination was found to be more satisfactory than Parshall or chute type flume structures since it handles both minimum and maximum discharges typical of the streams in this region without danger of clogging, thus overcoming the deficiencies of other kinds of structures. Moreover, the structure can be installed in a simple cut-off wall at comparatively low cost. A report on this study will be completed in time to serve as a basis for proceeding this season with stream gaging installations on experimental watersheds, the refinement of an open channel float, and rating tests.

4. Water Cycle Studies

A site has been selected near the Wasatch Branch Station and most of the equipment purchased for an installation to determine the extent to which plants on drained soils of mountain slopes utilize water that otherwise would be available for irrigation and other purposes in the valley lands. Losses of water from homogeneous soil profiles due to retention, evaporation and transpiration will be measured in interception pans and phytometers that are to be installed during the 1936 season.

5. Other Water Yield Studies

a. Snow survey courses established by the station at the Wasatch Branch and in Ogden Canyon have been added to the State network of snow courses, data from which is used for predicting irrigation water supplies.

b. Climatological and streamflow data from all of the stations in Utah are being compiled by N.Y.A. students as a basis for detailed studies of climate and streamflow relationships in this region.

## Flood and Erosion Control Studies

### 1. Flood Damage Survey

Comparable in seriousness to the water supply problem the occurrence of disastrous floods from partially aggraded canyon and accelerated erosion on the headwater and foothill slopes of the steep range-watershed lands constitutes another serious problem in the Great Basin, as was brought out by a survey of flood damage in Davis County, Utah. Here, due to the depletion of the plant cover on the headwaters of several small canyons, floods issued during the period 1923-1932 to cause $1,000,000 damage to a community valued at about $6,000,000. The character and amount of damage caused by these floods is shown in the following tabulation:

| | |
|---|---|
| Culinary and Irrigation Water Supply . . . . . | $ 60,256.00 |
| Improvements and Personal Property . . . . . | 142,908.00 |
| Land Incapacitated for Homes or Crops . . . . | 26,211.00 |
| Crop Losses, 3-year Period . . . . . | 89,861.00 |
| Clearing and Reconstructing Highways . . . . . | 69,861.00 |
| Clearing Railroads and Reconstruction . . . . | 73,500.00 |
| Reclamation of Agricultural & Residential Land | 30,546.00 |
| Miscellaneous . . . . . | 3,457.00 |
| Total Tangible Damage . . . . . | 496,600.00 |
| Property Value Decline Due to Flood Hazard . . | 556,905.00 |
| Total Damage . . . . . | $1,053,589.00 |

Lesser, but comparable flood damage -- all induced or accentuated by the depletion of the plant cover by overgrazing and fire -- has occurred in many other places in the State, clearly necessitating the development of methods for flood and erosion control.

### 2. Soil Fertility Losses

That soil fertility losses are an inevitable consequence of accelerated erosion and an important factor to be considered in rehabilitating depleted range-watershed areas is shown by an analysis of soil samples taken during the past year on eroded and uneroded portions of the Davis County watershed. Considering the organic matter, total nitrogen content, and the moisture equivalent of the soil as indices of fertility, this study revealed that the surface soil on uneroded areas is from 2 to 5 or 6 times more favorable to plant growth than on those areas which have been eroded. Moreover, as is shown in the table below, the quality of the soil decreased roughly in proportion to the degree of erosion, thus greatly accentuating the problem of rehabilitating the most seriously depleted areas for erosion control purposes.

A summary of soil fertility values in relation to the degree of erosion on the Davis County Utah watershed

| Fertility Indices | Erosion Class: None 6 Sites | | Light 4 Sites | | Moderate 5 Sites | | Heavy 7 Sites | |
|---|---|---|---|---|---|---|---|---|
| | 0"-3" | 4"-9" | 0"-3" | 4"-9" | 0"-3" | 4"-9" | 0"-3" | 4"-9" |
| Percent Organic Matter | 19.8 | 7.1 | 7.9 | 3.9 | 5.9 | 3.6 | 3.1 | 2.8 |
| Percent Total Nitrogen | .75 | .34 | .37 | .22 | .29 | .20 | .19 | .16 |
| Moisture Equivalent | 30.6 | 21.6 | 21.9 | 18.7 | 22.0 | 19.5 | 14.3 | 17.7 |

An interesting contrast of soil productivity was also revealed in a detailed study of two similar watersheds -- Emigration and City Creeks -- near Salt Lake City. Emigration Canyon has been subjected to unlimited grazing use and numerous fires since settlement, 80 or more years ago. City Creek has never been excessively used and for the past 40 years has been completely protected from fire and grazing. On the basis of 80 soil samples taken along transects at four different elevations in each watershed, it was found that the organic matter and the total nitrogen content of the surface six inches of soil in the heavily used Emigration Canyon watershed was only 62.2 percent and 68.8 percent, respectively, of that found in the protected City Creek area. The study also revealed, as summarized in the following table, that the greatest differences in soil fertility were observed at elevations above 6,800 feet, or on the areas most intensively used for summer range purposes. Although the original differences in the soils of these areas are not known, the inherent physical similarity of the two watersheds clearly suggests that the depleted condition of the soil in Emigration Canyon, in part at least, is a consequence of excessive use.

A summary of soil fertility values on adjacent watersheds near Salt Lake City having different grazing histories

| | Transect Elevations at Creek Bottom | | | | |
|---|---|---|---|---|---|
| | 5,000' | 5,350' | 5,600' | 6,800' | Average |
| | 20 Sites | 20 Sites | 20 Sites | 20 Sites | 80 Sites |
| | Percent Organic Matter (0"-6") | | | | |
| City Creek (40 yrs. protection) | 4.6 | 8.2 | 7.5 | 14.1 | 8.2 |
| Emigration Creek (60 yrs. heavy use) | 5.1 | 5.4 | 5.6 | 6.4 | 5.1 |
| Percent Difference | 67.4 | 65.8 | 74.7 | 45.4 | 62.2 |
| | Percent Total Nitrogen (0"-6") | | | | |
| City Creek | .19 | .33 | .31 | .42 | .32 |
| Emigration Creek | .15 | .25 | .23 | .27 | .22 |
| Percent Difference | 78.6 | 75.7 | 74.2 | 64.3 | 68.8 |

Soil fertility losses such as are indicated by these studies constitute one of the most serious obstacles to effective rehabilitation measures on depleted and eroding range watersheds because it is almost impossible on sites where the fertility has been diminished for desirable range plants to grow. On depleted range areas, therefore, it is apparent that erosion control measures must be aimed for the present at encouraging natural revegetation of the most promising annual weed type of cover, since plants of this general category appear to be the only ones capable of normal growth on impoverished soils. Rehabilitation in this direction may be of little immediate benefit from the grazing standpoint and may be only partially effective for erosion control purposes, but it is none the less necessary if ultimate range-watershed values are to be improved.

2. Terrace-Trench Erosion Control

The completion of terrace-trench erosion control work on about 500 acres of formerly eroding lands during the past two years has practically eliminated the menace of floods from 8,500 acres of the Davis County Utah watershed. Developed by the station and handled as a CCC project by the Wasatch Forest, this system has been applied to the headwaters of Parrish, Barnard, Ford, Davis and Steed Creeks, leaving only Farmington Canyon to be placed under control to complete this phase of the watershed protection program in the most critical part of Davis County.

The terrace-trench control work costs from $25 to $75 per acre of area treated, exclusive of reseeding and planting. Because of the cost, this system of control can be justified only where dependent values are high, such as in the Davis County area. Here local agencies are actively urging extention of this work to other canyons which have flooded in recent years.

Detailed profile surveys of the debris basins and the lower canyon section of Ford Creek were also made in connection with the terrace-trench work as a basis for measuring future deposition.

3. Artificial Reseeding on Terraced Areas

As part of the terrace-trench erosion control work on the Davis County watershed, an attempt was made in 1934 to hasten the revegetation of the terraced areas by means of artificial reseeding. Four species of grass including smooth brome, Kentucky blue, slender wheat, and winter rye, as well as a mixture of native weed seed, were sown in the fall of 1934. A check on this effort in 1935 revealed that whereas germination was very high, survival was a complete failure due to heaving of the seedlings out of the loose soil during the alternate freezing and thawing period in the spring and to severe drought during the summer. These tests clearly indicate some of the difficulties involved in artificial reseeding at high elevations and point to the need for further intensive study of methods that will insure reasonably successful results.

4. Great Basin Experimental Watersheds A and B

With the inauguration of a new system of treatment on the A and B watersheds in 1934, in which the herbaceous plant cover on B will be reduced to 16 percent of a ground cover by overgrazing while the cover on area A is maintained at 40 percent by conservative grazing, an analysis of the soil on the two areas was made during the past year as a basis for checking future changes in soil fertility. The data from this survey, as summarized in the table below, reveal that the organic matter and total nitrogen content of the soil on area A is only 87 and 89 percent, respectively, of the soil on area B. While no specific conclusions can be drawn from these data since the qualities of the soil prior to the start of the study in 1915 are not known, they are at least suggestive that soil losses have been more pronounced on the more rapidly eroding area A than on area B.

Table ___. The average percentage of organic matter and of the total nitrogen in the first and second six inches of soil on the Great Basin Experimental watersheds A and B.

| Area | Organic Matter | | Total Nitrogen | |
|---|---|---|---|---|
| | 0"-6" | 6"-12" | 0"-6" | 6"-12" |
| A (51 samples) | 4.135 | 3.412 | .2384 | .2089 |
| B (39 samples) | 4.746 | 3.938 | .2691 | .2220 |
| A - B ratio (Percent) | 87 | 87 | 89 | 94 |

5. Other Erosion Control Studies

a. Physiographic studies of areas including the climatic, geologic and ecologic factors influencing soil development on contrasting aspects were initiated during the past winter. Physical factor stations were installed temporarily on north and south aspects in the headwaters of Sardine Canyon near Logan, and in Ogden Canyon, and plans have been outlined for fundamental soil studies on these areas.

b. Studies for determining methods of controlling erosion on foothill range lands were started during the winter near Lime Canyon in the vicinity of Salt Lake City. Three paired watersheds of from 3 to 20 acres each and numerous uniform slopes for replicate plots are available for studying the effectiveness and cost of terrace trench, artificial reseeding, and natural revegetation erosion control methods. Surveys have been completed and plans developed for proceeding with this work as a CCC project in cooperation with the Wasatch Forest.

## Plans for 1936

1. Water Yield Studies

   a. The Farmington Canyon experimental watershed installations will be completed insofar as funds will permit. This work will include soil and plant inventories and the establishment of climatic control stations, as well as the construction of stream gaging stations, roads, trails and a shelter cabin.

   b. The Parrish Creek water cycle installation will be completed including detailed soil studies and the establishment of climatic control.

   c. Absorption of surface water by soils as influenced by plant cover and soil texture will be studied with portable apparatus.

   d. Compilation of water supply data will be continued.

   e. Cooperative snow survey work will be continued.

   f. A stream gaging station will be installed on Ephraim Creek and the area A and B watersheds maintained.

2. Erosion Control Studies

   a. Technical direction of terrace-trench erosion control work on the Davis County watershed will be continued, supplemented by natural and artificial revegetation studies on controlled areas.

   b. The Lime Canyon watersheds will be completed for determining the cost and effectiveness of erosion control methods on foothill range lands.

   c. The effectiveness of different kinds of plant cover for controlling run-off and erosion will be tested by means of portable apparatus.

   d. Physical studies of soil formation and creep on contrasting aspects will be refined.

## BOISE EROSION

Accelerated erosion and inadequate water supplies are two of the most important problems affecting the agricultural, industrial and social development of the Snake River Valley in Idaho. These problems have become especially serious in Boise Valley. Here an investment of about $55,000,000 in 350,000 acres of fertile valley land and water developments, has been threatened by excessive silting and water shortages, due to accelerated erosion on an inadequate streamflow from the 1,700,000-acre Boise River range-watershed. The current results of studies of the erosion and water yield problems on this watershed and their significance in relation to the management of approximately 27,000,000 acres of comparable range watershed lands within the Snake River drainage follow:

### EROSION CONTROL STUDIES

#### 1. The Effectiveness of Range Cover for Controlling Run-off and Erosion

Bunchgrass (Agropyron spicatum) typical of the virgin range on the Boise River watershed is 113 and 1,230 times more effective for controlling run-off and erosion, respectively, than is the average of three kinds of range cover which are now found on depleted portions of this watershed. These and other significant values summarized below were derived from measurements made with portable rainfall equipment during the past two years on ninety-six 1/200-acre plots of which 24 each were on bunchgrass, downychess, needlegrass-lupine, and annual weed range types.

On bunchgrass cover plots only 4/10 of 1 percent of applied rainfall ran off and the equivalent of only 6 pounds of soil per acre were removed, as compared to an average of 45.4 percent run-off and 7,382 pounds of eroded material per acre on the other three kinds of cover plots studied. Moreover, as is shown in the tables below, the bunchgrass cover was equally effective when subjected to high as well as low rainfall intensities, when on 40 as well as on 30 percent slopes, and when the surface soil was thoroughly disturbed to simulate excessive trampling by grazing animals as compared to undisturbed soils. It thus appears that the bunchgrass cover type, with its dense stand of fibrous-rooted plants, is by far the most desirable of the four kinds studied for watershed protection purposes. In view of the fact that the bunchgrass cover is also of superior value for grazing purposes, it is obvious from a practical range-watershed administration standpoint that every effort should be made to restore this kind of cover on depleted areas.

Table I. The relative effectiveness of four typical cover types for controlling run-off from the granitic soils of the Boise River watershed under two conditions of rainfall intensity, slope, and soil disturbance, as indicated by the percentage of run-off of 1.80 inches of artificial rainfall from 1/200 acre plots.

| Test Conditions | COVER TYPES | | | | |
|---|---|---|---|---|---|
| | 1 Bunchgrass (Agropyron spicatum) 24 plots | 2 Downy Chess (Bromus tectorum) 24 plots | 3 Needlegrass-Lupine (Stipa-Lupinus) 24 plots | 4 Annual Weed 24 plots | Average of 2, 3 and 4 72 plots |
| Average of all conditions | 0.4 | 25.5 | 49.9 | 60.8 | 45.4 |
| Low Intensity Rainfall | 0.4 | 16.5 | 41.6 | 57.2 | 38.4 |
| High Intensity Rainfall | 0.4 | 34.5 | 58.2 | 64.4 | 52.3 |
| 30 Percent Slope | 0.5 | 12.2 | 55.6 | 60.0 | 41.2 |
| 40 Percent Slope | 0.3 | 38.7 | 44.3 | 65.6 | 49.5 |
| Undisturbed Soil | 0.5 | 23.4 | 49.7 | 58.2 | 43.7 |
| Disturbed Soil | 0.3 | 27.6 | 50.1 | 63.4 | 47.0 |

Table II. The relative effectiveness of four typical cover types for controlling erosion on the granitic soils of the Boise River watershed under two conditions of rainfall intensity, slope, and soil disturbance, as indicated by the pounds per acre of soil eroded from 1/200 acre plots during artificial storms of 1.80 inches.

| Test Conditions | COVER TYPES | | | | |
|---|---|---|---|---|---|
| | 1 Bunchgrass (Agropyron spicatum) 24 plots | 2 Downy Chess (Bromus tectorum) 24 plots | 3 Needlegrass-Lupine (Stipa-lupinus) 24 plots | 4 Annual Weed 24 plots | Average of 2, 3, & 4 72 plots |
| Average of all conditions | 6 | 2,101 | 4,766 | 15,280 | 7,382 |
| Low Intensity Rainfall | 6 | 579 | 2,960 | 12,976 | 5,505 |
| High Intensity Rainfall | 6 | 3,624 | 6,573 | 17,583 | 9,260 |
| 30 Percent Slope | 6 | 562 | 4,660 | 4,789 | 3,337 |
| 40 Percent Slope | 6 | 3,640 | 4,873 | 25,770 | 11,428 |
| Undisturbed Soil | 6 | 940 | 3,359 | 12,006 | 5,435 |
| Undisturbed Soil | 6 | 3,263 | 6,174 | 18,554 | 9,330 |

The downy chess (Bromus tectorum) cover type, which has invaded bunchgrass areas following fire and overgrazing, was found to be fairly effective for controlling run-off and erosion under moderate intensities of rainfall, on gentle slopes, and when the soil was not disturbed, although on the average more than 63 percent more run-off and 300 times more erosion occurred on this than on bunchgrass areas. When subjected to high intensities of precipitation, on steep slopes, and under conditions of disturbed soil, however, the shallow roots of the plants in this type were even more noticeably inefficient. Under the latter conditions, run-off increased significantly and erosion was greater by from more than 300 to nearly 700 percent. This phase of the study reveals that there is an urgent need for inaugurating management practices which will insure a rapid recovery of the original bunchgrass on downy chess range lands. The data also indicate that until a more efficient plant cover is restored, soil erosion losses on the downy chess range can be held to a minimum by avoiding excessive trampling and by restricting grazing to gentle slopes.

The needlegrass-lupine (Stipa lupinus) cover type which is common on overgrazed range at high elevations, and the annual weed type which is typical of seriously depleted areas along stock driveways were found to be least effective for watershed protection purposes. On the average, from 124 to 152 times more run-off and from 781 to 2,546 times more erosion occurred on plots in these two types as compared to plots on bunchgrass range. This suggests the extent to which soil losses are occurring on depleted watershed lands and points to the obvious need for immediate rehabilitation measures.

A detailed description of the portable apparatus used in this study has been mimeographed for limited circulation. A technical report on this study is nearing completion.

2. Natural Revegetation Studies

The reestablishment of desirable range-watershed cover conditions by natural revegetation is destined to be a slow process on areas where range depletion has progressed to an advanced stage, according to an analysis of comparative range areas on the Boise River watershed during the period 1931 to 1934. Range vegetation which had not been seriously depleted prior to 1931 maintained a fair density during the drought period, 1931-1934, both when protected and grazed as is shown in the table below. On the other hand, the vegetation on seriously depleted range areas declined sharply during the same period, even when protected from grazing. Although it is recognized that this 4-year period was characterized by severe drought, the slowness with which range improvement is being obtained under complete protection from grazing use, clearly suggests the need for further investigations aimed at hastening this process, such as studies of artificial reseeding.

Table III. The changes in plant density on severely and moderately depleted range lands during the period 1931-1934.

| | Severely Depleted | | Moderately Depleted | |
|---|---|---|---|---|
| | 1931 | 1934 | 1931 | 1934 |
| | Protected from Grazing | | | |
| Total Density | .070 | .010 | .057 | .057 |
| Perennial Density | .008 | .009 | .051 | .057 |
| Annual Density | .062 | .001 | .006 | T |
| | Grazed Range | | | |
| Total Density | .077 | .013 | .053 | .030 |
| Perennial Density | .011 | .010 | .032 | .030 |
| Annual Density | .066 | .003 | .021 | T |

3. Soil Depletion -- An Obstacle to Range Rehabilitation

The difficult edaphic conditions under which range rehabilitation must be carried forward, either on a natural or artificial basis, are illustrated by a comparison of the chemical and physical properties of the surface soil on uneroded, moderately eroded and heavily eroded areas on the Boise River watershed. Based on the analysis of 67 samples taken over the watershed, as summarized in the table below, this study revealed that eroded soils have lost nearly 75 percent of their original nitrogen content and organic matter, and 43 percent of water holding capacity, and as a result are not favorable for plant growth.

Table IV. The percentage of total nitrogen and organic matter and the water holding capacity of comparable granitic soils under these stages of erosion.

| | Uneroded | Moderately Eroded | Heavily Eroded |
|---|---|---|---|
| Total Nitrogen | .184 | .077 | .048 |
| Organic Matter | 5.24 | 2.09 | 1.29 |
| Water holding Capacity (Hilgard) | 79 | 57 | 45 |

The extent to which elements favorable to plant growth are washed from the granitic soil of the Boise River watershed as the result of one artificial rainstorm indicates the urgent need for restoring an effective plant cover for preventing a continuation of accelerated erosion before further depletion of the soil occurs. The data in the table below were obtained from the analysis of soil samples on 1/200-acre plots before and after being subject to an artificial rainstorm of 1.80 inches, and from soil eroded off of each. These data show that erosion tends not only to remove the finer fractions of soil, leaving coarse material as an erosion pavement, but that the surface soil may lose as much as 20 percent of its organic matter and nitrogen in a single rainstorm.

Table V. The change in physical character and loss in plant nutrients of the surface half inch of soil as a result of a single storm of 1.80 inches.

| Soil Fractions | Surface Soil | | Eroded Material |
|---|---|---|---|
| | Before Rain | Following Rain | |
| | % | % | % |
| Gravel | 20.0 | 18.9* | 3.7 |
| Sand | 33.7 | 34.9* | 33.3* |
| Silt | 8.3 | 7.8* | 20.5 |
| Clay | 4.2 | 3.9* | 9.2 |
| Organic Matter | 3.05 | 2.44 | 5.35 |
| Total Nitrogen | .147 | .117 | .229 |

* Not significantly different from value for soil before rain.

4. Other phases of erosion control studies upon which work was done during the year included:

   a. The start of a series of tests with portable erosion apparatus on 50 percent slopes to supplement run-off and erosion data already obtained on 30 and 40 percent slopes.

   b. The start of tests to determine the influence of length of slope on run-off and erosion by means of portable equipment.

   c. The completion of drawings for and the editing of a paper on a study of range plant root systems, to be offered for publication by L. E. Spence as collaborator.

## WATER YIELD STUDIES

### 1. Water Absorption by Surface Soils

That herbaceous range plants materially increase the rate of surface water absorption by the soil and thus, by inducing infiltration of water to underground channels, may be a potent factor in sustaining valuable summer streamflow from range watershed areas, is clearly suggested by water absorption studies that were made with portable equipment on the Boise River watershed during the past year. In this study the rate of absorption of water by the surface soil was measured on 40 pairs of 1-foot square plots. In each pair, one plot was on barren ground while the other was on an adjacent area supporting a growing plant. Of the 40 pairs of samples, 12 were on areas characterized by perennial range plants having fibrous root systems, while 28 were on range characterized by annual weeds with tap root systems.

Soils having a plant cover absorbed water 65.7 percent more rapidly than when bare, as is shown in the table below. Of greater significance from a range as well as a watershed management standpoint, areas supporting fibrous-rooted plants typical of good range land absorbed water 127 percent more rapidly than adjacent barren plots, whereas, on areas supporting inferior range cover, the presence of taprooted plants increased the rate of absorption over that of bare areas only 51.5 percent. In other words, these data show that fibrous-rooted range species are about 2½ times more effective in increasing the rate of absorption of surface water by the soil than are taprooted species.

Table VI. The rate of absorption of surface water by the granitic soils of the Boise River watershed as influenced by the presence of plants

| Type of Plant Cover | Rate of Absorption on vegetated plots (Inches per Minute) | Rate of Absorption on barren plots (Inches per Minute) | Percent Increase in Rate of Absorption |
|---|---|---|---|
| All Species | .0658 | .0397 | 65.7 |
| Fibrous-rooted plants | .0809 | .0356 | 127.0 |
| Taprooted plants | .0606 | .0400 | 51.5 |

When it is considered that most of the water storage problems in this region are due to a rapid run-off of melted snow water in the early spring followed by a low summer flow that is inadequate for meeting irrigation and other requirements, any delay in the peak spring flow and any increase in the volume of summer flow is of obvious benefit to water users. The extent to which the regimen of mountainous streams may be altered in this direction by range vegetation cannot be predicted from this study, but the fact that the presence of desirable plants greatly increased absorption of the surface water by the soil and thus minimized surface run-off, suggests that the usability of streamflow may be improved by the restoration of the original perennial plant cover on depleted range watersheds.

A report on this study has been submitted to the Journal of Forestry.

2. Water Cycle Installation

The installation of a battery of six 2-milacre steel lysimeters on the Boise Basin Experimental Forest was completed during the past season as part of a study of the influence of range plants on evapotranspirational losses from soil profiles. This work, done largely with CCC and ERA help, included (1) the refilling of the tanks with a homogenous mixture of soil without tamping, an alteration considered necessary because of excessive difference in seepage during the first year when the soil was placed in the tanks by tamping to simulate original conditions; (2) the installation of multiple point float gages on the surface and seepage flow collector tanks; and (3) the construction of a shelter house and installation of a battery charger for housing and maintaining power for a multiple pen recorder. Plans were also developed and most of the equipment purchased for completing the installation of a physical factor station and a battery of interception pans and phytometers.

3. Bannock Creek Experimental Watersheds

Two 11-acre experimental range-watersheds in the Boise Basin Experiment Forest were put in final shape for measuring surface and seepage flow. Work on these areas included (1) a detailed plant inventory, (2) the installation of a combination tipping bucket-flow meter for registering seepage flow; and (3) a reconnaissance of the snow mantle as a basis for the installation of snow stakes and rain gages.

4. Arrowrock Range-Watershed Reconnaissance

Recognizing the need for experimental watersheds on typical range areas that will be suitable for studying the influence of utilization on run-off and erosion, a detailed inspection was made of 73 tributary drainages in the vicinity of Arrowrock Dam during the summer. One set of three desirable watersheds of about 150 acres each were located in Woodtick Creek and another set of four of about 400 acres each were found in Grouse Creek. Plans have been outlined for installing stream gaging and debris measuring devices on these areas and for

experimental studies of erosion control methods by means of natural revegetation, artificial reseeding, and engineering works. A large part of this work is contingent upon the availability of CCC or other help and the adjustment of grazing practices by private land owners.

## Plans for 1936

1. Erosion Control Studies

   a. The effectiveness of different kinds of cover for controlling run-off and erosion will be studied by means of portable apparatus, with special reference to areas on which reseeding work is to be done for erosion control purposes.

   b. Natural revegetation plots will be remapped and new plots added to the network as a check on the rate and character of range improvement under different intensities of use.

   c. Experimental range watersheds will be developed in the vicinity of Arrowrock Dam for measuring run-off and erosion as influenced by different erosion control measures, including improved systems of grazing, natural revegetation, artificial reseeding, and engineering works.

   d. Technical direction will be extended to erosion control work by the southern Idaho Forests.

2. Water Yield Studies

   a. The absorption of surface water by soils as influenced by plant cover and soil texture will be continued by means of portable apparatus.

   b. The Bannock Creek water cycle installation will be completed by adding a battery of interception pans and phytometers to the present system of lysimeters.

   c. The Bannock Creek experimental watersheds will be maintained and improved.

   d. Climatic and streamflow data compilations will be maintained and cooperation on snow survey work continued.

   e. Economic studies of watershed-valley relationships will be continued.

   f. Locations for studying water yield from timbered watersheds will be investigated and plans developed for initiating these studies.

## FOREST MANAGEMENT (SILVICAL RESEARCH)

During 1935 forest management emphasized the investigation of factors influencing the establishment, survival, and growth of natural ponderosa pine reproduction. Coincidentally, studies were also made on planting and root-soil moisture relationships, the moisture content of evergreen leaves, methods of cutting, timber stand improvement, fire, and other miscellaneous problems. Results of these studies, most of which were made on or near the Boise Basin Experimental Forest, and plans for 1936 are summarized below.

### 1. Natural reproduction of ponderosa pine

Substantiating earlier studies which indicated that unsatisfactory reproduction of ponderosa pine is common on cut-over and burned areas in the forests of central Idaho, an intensive survey in 1935 provided further information regarding the occurrence and survival of ponderosa pine seedlings and a basis for starting a detailed study of the factors influencing reproduction of this important species.

The unusually abundant seed crop in 1934 and favorable germination conditions in the spring of 1935 made the past season a particularly favorable one to study occurrence and survival of seedlings under natural conditions. To accomplish this purpose, transects were established on cut-over, recently burned-over, and virgin timber areas. Treating each seedling as an individual plot, the following significant results were derived from this survey:

#### Occurrence

a. Seedlings are relatively abundant up to 100 feet from seed trees. Beyond that distance scarcely any seedlings were found. Within the 100-foot zone survival of the natural seedlings decreased as the parent seed tree was approached. These relationships indicate the desirability of more and better spaced seed trees and also why more than twice as many seedling per acre were found in virgin than in cut-over stands.

b. Under virgin forest conditions three times as many seedlings per acre were found on the south slopes as on the north slopes. In cut-over areas more seedlings were found on north slopes. Under both conditions, however, survival in percent was higher on north slopes. Both occurrence and survival increased with decrease in slope. Seedling survival on disturbed soil on cut-over areas was twice as great as on undisturbed soil in the same area.

Survival

c. Drought was the principal agent causing mortality. Out of the 47 ponderosa pine seedlings per acre occurring on the cut-over area only 20 survived the first year, drought being responsible for 90 percent of the loss. In the virgin forest only 16 ponderosa pine seedlings per acre out of the 124 germinating survived, drought causing 82 percent of the mortality.

d. On an area burned over in the late summer of 1934, slightly over 800 seedlings per acre survived the 1935 season in a heavily burned virgin stand, approximately 275 per acre in a lightly burned virgin stand, 10 per acre in a heavily burned cut-over stand, and 220 per acre in a lightly burned cut-over area.

e. On a 4-year-old burn a total of 96 post-fire seedlings per acre were found in a partially killed stand and no seedlings whatsoever in a stand heavily burned and completely killed. The comparison between the 1931 and 1934 burns shows readily the difference in the rate of restocking to be expected when fires occur in good seed years, 1931 having been a poor seed year.

f. Soil moisture relationships were found to have been considerably better on the 1934 burned area as compared to unburned areas, available moisture at 18-inch soil depth being present throughout the season on the former. Other factors such as soil depth, soil texture, amount of debris, litter depth and kind, lesser vegetation, and type of tree producing the seed, were also found to be related to seedling survival.

On the basis of these observations, a more detailed study of reproduction was initiated on areas where most of the important factors influencing occurrence and survival can be controlled. A rodent-proof and a stock-proof exclosure were established on each of a north and south slope and on a flat. Within these enclosures 24 conditions are to be isolated and studied in triplicate, representing varying degrees of moisture, shade and litter cover. Seedling plots representing each of the combination of factors to be studied were planted with local seed in the fall, and detailed observations will be made during the 1936 season. A study of the quantity of cones and seed produced by different sizes and classes of trees was started beginning with comparatively fundamental relationships of flower and cone developments. An investigation of seed distribution by use of seed traps was begun also.

## 2. Planting and root studies

As shown by the natural reproduction studies on certain burned-over areas, it will be necessary to resort to planting in Region 4 if satisfactory regeneration of burned areas is to be expected. With this in mind, the planting studies reported in 1934 were continued in 1935 with results quite similar in both years. The 1935 information verified the previous observations in that drought was the major factor causing mortality, that the success of planting varied greatly according to exposure and slope, and that if planting is to be continued by the administrative organizations the planting sites must be selected very carefully and no attempt should be made to plant entire drainages, no matter how small, without regard to site within these drainages.

Oftentimes natural seedlings were observed to have survived when nearby planting stock had suffered very heavy losses. Owing to several reasons, improper planting was eliminated as the basic cause of this marked difference in survival, and attention became focused on the root development of natural versus planted seedlings. It was found that at the close of the season the 1935 seedlings on a burned-over area had a root system averaging 27 inches in length with a top only 3.5 inches in height. The root system was characterized by a considerable length of laterals, but the dominant growth and development was centered around the single taproot, this taproot having been able to keep within the zone of available moisture throughout the summer. In contrast, the planting stock (2 and 3 years old when planted) had a large, fibrous surface root system with no distinct taproot. The root length was approximately 12 inches and the top length 5 to 8 inches. When the latter trees are planted a distinct taproot develops very slowly because of the shock of transplanting and the root pruning practices which removed the growing tips from the larger, dominant roots. As the season progresses, soil desiccation exceeds the rate of extension of the roots and the plants die for lack of available water.

Root studies were further extended to a comparison of the development of roots of 1-year-old seedlings found on burned areas to those on virgin areas. It was found that on October 1 the average depth of roots on the 1934 burn and virgin areas was 27 and 9.4 inches, respectively -- the average weight of the latter being approximately one-tenth of that of the former. The average number of laterals per seedling in the virgin forest was 36 with a total length of 6.7 inches, while on the burned area the average number was 183 with a total length of 118.7 inches. This marked difference in development is attributed largely to the difference in soil moisture available, and to a very much lesser degree, the soil itself. Growth of roots was found to continue throughout the summer in both areas, while top growth stopped by August 1.

In addition to the investigations of initial root development, the morphology of roots of 2- and 3-year-old natural seedlings on cut-over areas was also studied. This phase of the study revealed that the average depth reached by 2-year-old seedlings was 30.5 inches, while the 3-year-old seedlings extended 49.7 inches; that the root system has a definite tendency to be "two-storied" thereby taking advantage of surface and deeper levels of available moisture; and that the top-root ratio, both on the basis of length and weight, increases with age.

The implication and value of these root-soil moisture relationship studies are far reaching and self evident. It is paramount to point out, however, that regeneration of burned areas should be stressed the year immediately following fire. Careful examination of the seed crop will indicate whether or not artificial measures should be used.

3. Trends of moisture content in evergreen foliage during periods of drought stress

This study was undertaken in 1934 in an attempt to determine the factors influencing and causing the extreme fire hazard of certain years in the ponderosa pine forests of central Idaho. The 1935 work was patterned largely after earlier work and in general confirmed the preliminary conclusions.

As previously reported, 2- and 3-year-old pine needles and Ceanothus leaves were used for the study. Statistical analyses of both 1934 and 1935 data show that variations in moisture content of needles caused by the date the sample is taken, the position of the sample on the tree, the site on which the tree is growing, and the tree itself are significant. None of the interactions of these variables are significant.

During the past season the sampling began April 25, at which time the moisture content of the 2- and 3-year-old needles was approximately 103 percent; by May 4 a decline to 96 percent had been observed; from May 4 until September 15 the moisture content of the needles rose quite consistently, reaching a high point for the season at approximately 115 percent; after September 15 the moisture content again dropped until 106 percent was reached, when the study closed on November 21. Ceanothus foliage, on the other hand, had an average moisture content of approximately 108 percent on April 25, rising to 138 percent June 24, and then declining steadily and rapidly to the close of the season with a low of 94 percent October 24.

As a check on the methods used and to determine similar trends for pine needles of the current year's growth, sampling of 1-year-old needles was begun July 25. A moisture content of 181 percent was found in the initial samples, and in direct contrast to the trend in the older needles, the young needles became more desiccated as the season progressed, reaching a low of 124 percent on October 8.

The significant trends observed in 1934 and 1935, the consistency of the relationship of date, position of leaves on tree and site to moisture content, and the very definite contrasting trend of the moisture in the current year's growth as compared to older needles are sufficient empirical evidence to indicate that the methods used are satisfactory and the observations recorded are real phenomena. No further work is planned on this study until detailed physiological investigations are possible. Without doubt, the facts revealed by this study afford a valuable approach to the study of the water and food relationships of evergreen trees. This field, vast though it is, should be explored further at the earliest possible date. A paper on this study will be prepared as rapidly as possible in an effort to arouse interest in the observed phenomena among plant physiologists in general.

4. Methods of cutting ponderosa pine

Reproduction transects on the method of cutting plots within the experimental forest were reexamined and the cone crop of the various reserve stands studied. The immediate information forthcoming from these plots deals with damage to reproduction caused by caterpillar logging, the study being based upon an intensive investigation of 72 acres.

The methods of cutting report for the region as a whole based on surveys of several large national forest cut-over areas is in the process of compilation and should be in report form before the close of the calendar year.

5. Timber stand improvement in the ponderosa pine type

The 25 stand improvement plots designed for investigative and demonstrative purposes on the experimental forest were further improved by slash disposal on certain blocks. The stand improvement work was expanded further to include stand 60-70 years of age where cordwood cuttings were made and the crop trees of the reserve stand pruned. The timber stand improvement work has been done with ECW funds as an aid in perfecting woods practice for CCC camps.

Damage to crop trees from snow breakage was studied and in no case was any loss observed in trees larger than 5 inches D.B.H. Loss increased with decreasing diameter until a maximum 12 to 15 percent of the crop trees in the 1- and 2-inch D.B.H. classes were killed.

6. Fire

The vegetative and reproduction transects on the 1931 fire area were reexamined. A report on the fire damage to the forest cover was published in the January 1936 number of the Journal of Forestry.

At the request of the Regional Office the station cooperated in a study of speed of fire line construction on going fires. The station cooperated with the Region, also, in supervising the collection and making the compilation of fire hazard information as determined from wood cylinders and duff hygrometers.

7. Miscellaneous

A series of minor unclassified studies upon which progress has been made merit mention by way of conclusion. Snow studies have been carried forward, one phase of the work dealing with the relation of snow cover to forest growth, and another dealing with accumulation and rate of melting of snow as influenced by methods of cutting. Phenological studies of both forest trees and lesser vegetation are under way on the experimental forest. A brief review of truck logging in central Idaho was made and an article on the subject written and accepted for publication by the American Lumberman. The effect of slope on soil temperature has been studied for the past two years. A nursery was established on the experimental forest for various investigations requiring this facility. Assistance was furnished in planting the Davis County, Utah erosion control terraces to Douglas fir. At the close of the first year 35 percent of the trees planted on this project were still living.

## Plans for 1936

1. Continued effort will be made to close the ponderosa pine cut-over land study by means of a comprehensive report. The damage to reproduction by caterpillar logging will be closed by means of a report also. Emphasis will be placed on compilation of existing data collected in 1935 and as rapidly as possible data will be placed in completed office form so that as time progresses and additional information becomes available reports can be prepared rapidly and with the minimum of compilation.

2. Field work for the coming year will be concentrated on the natural reproduction study. The detailed physical factor problem in relation to germination and survival will be intensively investigated. Cone and seed production studies will be continued, and further investigation will be made of the natural reproduction transects established in 1935.

3. Methods-of-cutting plots on the Payette and Salmon National Forests will be remeasured and reproduction transects established 5 years ago, both in cut-over and virgin stands on the forests, will be rechecked.

4. Stand improvement work will be continued on an experimental scale, stressing a study of the rate of natural pruning as contrasted to artificial pruning in stands 60-70 years of age.

5. Planting and root studies will be continued to the extent that available labor permits. These are studies so broad in scope and offer such valuable and interesting possibilities that any expansion of activity will be directed in their direction.

6. Minor studies, dealing with vegetative trends on fire areas, accumulation and rate of melting of snow as influenced by methods of cutting, and phenology will be continued.

7. Further physical development and improvements of the experimental forest will be hastened. The rate of construction of utilization roads and firebreaks, insect control, etc., depends on the availability of CCC and other types of emergency labor.

8. Cooperation in collection of any analysis of fire hazard data with Region 4 will be intensified, and the Experiment Station will take a more active part in the studies outlined by the administrative force.

9. Cooperation will be extended to the Institute of Forest Genetics, California Forest and Range Experiment Station, and nursery space provided for a source of seed study planned to begin in 1936.

## RANGE MANAGEMENT INVESTIGATIONS

Range investigations during the past year were conducted on four major projects. These include studies on (1) summer range lands of the Wasatch Plateau at the Great Basin Branch Station near Ephraim, Utah, (2) spring-fall range lands of the sagebrush-wheatgrass type in southeastern Idaho at and near the U. S. Sheep Experiment Station, Dubois, Idaho, and (3) winter range lands of the desert shrub type centering at the Desert Range Branch in western Utah, and (4) artificial reseeding and plant breeding investigations. Current results of these studies, and plans for each during 1936 follow:

## SUMMER RANGE - WASATCH PLATEAU

Summer range studies at the Great Basin Branch Station during the past year included the analysis and preparation of reports on phenological and climatic data relationships, artificial reseeding tests, the character of mountain climate, plant nutrition, and the germination of range plants, as well as routine field and office work on plant vigor, natural revegetation, and climate and plant growth studies. A summary of these efforts is given below.

### 1. Forecasting range conditions

A simple and reliable method of predicting future stages of range plant development has been perfected by correlating 10-year records of phenological and climatic data at the Great Basin Branch Station. This method was developed from mathematical equations that were derived from relationships between the date of snow disappearance and the number of days from the time snow leaves to dates on which certain stages of development are reached. In use, it is necessary simply to note the date of snow disappearance and, by referring to the constructed tables, read the number of days required to reach the various stages of development.

This method was found to be successful in predicting plant development stages under different conditions of elevation, slope and exposure during the past season. In many instances the predicted date, which was made from 3 weeks to over 3 months in advance, coincided with the actual date of development, and in no case was the predicted date in error by more than 10 days.

Aside from offering a means of predicting range conditions in advance, which will materially aid administrative planning, the present data also brought out the fact that the seasonal development of range plants varies widely between years. This fact emphasizes the importance of making the opening and closing dates of grazing more elastic in order to adjust for the extreme variation in seasonal development of range plants.

The above data have been completed in written report form. The report "Climate and Plant Development in Relation to Range Management" is now in the hands of an editor.

2. Artificial reseeding - oakbrush type range

Oakbrush type range lands can be successfully reseeded with common bromegrass (Bromus inermis), many-flowered bromegrass (Bromus polyanthus), and crested wheatgrass (Agropyron cristatum), while white sweetclover (Melilotus alba) and yellow sweetclover (Malilotus officinalis) are not satisfactory for this purpose, according to tests conducted on this type of range during the 1929-1935 period at the Great Basin Branch Station.

The carrying capacity of experimental plantation plots located at the lower limits of the oakbrush type range was increased 222 percent by sowing many-flowered bromegrass, 281 percent by sowing crested wheatgrass, and 719 percent by sowing common bromegrass. At the upper reaches of the oakbrush type increases of 95 percent, 31 percent, and 159 percent were obtained by sowing many-flowered bromegrass, crested wheatgrass, and common bromegrass, respectively.

Successful results were obtained by both spring and fall sowing, although on the average, fall sowing was somewhat more satisfactory. Seasonal precipitation and the germinative requirements of the seed used seem to be the limiting factors.

The methods of sowing and soil treatment, together with the cost of each used in the study, rank as follows:

a. Seed sown broadcast on plowed furrows spaced at 3 feet and covered with a brush drag . . . . . $6.00 per acre

b. Seed sown broadcast on plowed furrows spaced at 3 feet with no further treatment . . . . . $4.50 per acre

c. Seed sown broadcast on bare ground and trampled with sheep . . . . . $0.80 per acre

d. Seed sown broadcast on bare ground with no further treatment . . . . . $0.65 per acre

The above cost figures do not include the cost of the seed. By adding the cost of the seed and the cost of livestock protection during the period of establishment these costs might be doubled temporarily. However, with such increases in carrying capacity as noted, the reseeding of sagebrush swale types within the oakbrush type range with the above named species is recommended.

A report, "The Results of Artificial Reseeding Trials on an Oakbrush Type Range," is in the hands of an editor.

3. Variation of precipitation of a high mountain range area

The variability of occurrence and other interesting aspects of precipitation on the Wasatch Plateau have been brought out in a careful analysis of climatic records that have been taken at observation points in the vicinity of the Great Basin Branch Station during the past 20 years.

According to this study, which is partially summarized in the following table, the amount of precipitation increases rapidly from the valley floor to an elevation of approximately 9,000 feet, above which it decreases slightly. On the average, annual precipitation increases 3.6 inches per thousand feet rise for the entire front of the plateau. Departures from this rate of increase are considerable during the year, however, the minimum being an increase of only 0.69 inch per thousand feet rise in June and a maximum of 8.25 inches per thousand feet rise in January. Variations in precipitation per thousand feet rise are also evident between vegetational zones. These are:

## VARIATION OF PRECIPITATION

### WASATCH PLATEAU

| | Pinyon-juniper zone 5,575 ft. | Oakbrush zone 7,650 ft. | Aspen-fir zone 8,850 ft. | Spruce-fir zone 10,100 ft. |
|---|---|---|---|---|
| ANNUAL PRECIPITATION | 11.70" | 17.51" | 29.48" | 28.01" |
| SEASONAL PRECIPITATION (October 1 to May 1, in percent of annual) | 61% | 62% | 71% | 73% |
| AMOUNT OF INDIVIDUAL STORMS | 0.12" | 0.21" | 0.20" | 0.20" |
| NUMBER OF RAINY DAYS (May 1 - November 1 period) Total number of days | 46 days | 41 days | 54 days | 44 days |
| No. of days with 0.25 inch or more | 7 days | 13 days | 14 days | 12 days |
| No. of days with 0.50 inch or more | 2 days | 4 days | 6 days | 4 days |
| DROUGHT PERIODS No. of rainless days between storms of 0.05 inch or more | 12 days | 8.9 days | 7.6 days | 8.5 days |
| No. of rainless days between storms of 0.50 inch or more | 109.1 days | 59.6 days | 33.8 days | 40.2 days |
| SNOWFALL (In percent of annual precipitation) | 45% | 60% | 70% | 80% |
| Average Depth | - | 24.9" | 47.3" | 52.9" |
| Average date of snow disappearance | | April 18 | May 6 | May 26 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 2.8 | inches | increase | per | thousand | feet | rise | between | pinyon-juniper and oakbrush zones |
| 10.2 | " | " | " | " | " | " | " | oakbrush and aspen-fir zones |
| 1.2 | " | decrease | " | " | " | " | " | aspen-fir and spruce-fir zones |

Monthly precipitation. Monthly precipitation for the area varies widely. Precipitation is least during June and heaviest during March in all zones. Amounts are grestest during the early spring months (March and April), decreasing to the annual minimum in June. A secondary rainy season occurs during July and August followed by a dry period during September. Thereafter, amounts increase during the winter and reach the annual maximum in March.

Precipitation by 5-day periods. Precipitation by 5-day periods shows that the greatest precipitation occurs during the period May 26-31, averaging 0.55 inch. The driest period occurs during the period June 21-25, averaging 0.07 inch. The summer maximum occurs during July 26-31, averaging 0.50 inch.

Other variations, such as average amounts of individual storms and average date of snow disappearance for the mountain area are evident as shown in the table.

Trend of precipitation. Precipitation records for the plateau area indicate considerable periodic variations. In the pinyon-juniper zone at Manti, Utah annual precipitation during the past 34 years has averaged as follows:

| | | | | | |
|---|---|---|---|---|---|
| 1901 - 1904 | 9.69 | inches, | 21 | percent | below normal |
| 1905 - 1909 | 17.06 | " , | 39 | " | above " |
| 1910 - 1922 | 12.95 | " , | 6 | " | " " |
| 1923 - 1930 | 11.28 | " , | 8 | " | below " |
| 1930 - 1934 | 7.88 | " , | 36 | " | " " |

During the 12 years, 1923-1934, there were only two years of above normal precipitation (1927, 1930).

Similar data have been worked up for atmospheric temperature and to a limited extent for soil temperature, soil moisture, evaporation, humidity, wind movement and sunshine duration for the plateau area. A report based on this study, "Climate of the West Front of the Wasatch Plateau in Central Utah", is in the hands of an editor.

4. Germination of seeds of summer range plants

The requirements for the germination of seeds of summer range plant species have been found to differ widely according to recently completed studies of 42 of the common species on the Wasatch Plateau summer range. Using seed from 9 grass, 26 weeds, and 7 woody species, this study revealed that whereas seed of some plants requires alternate moistening and drying before germination is satisfactory, the seed of other species is not affected by these conditions. Temperature and periods of storage were also found to be important factors influencing germination in varying degrees according to species.

This study explains in part why germination of some species is especially high in certain years and low in others, and clearly suggests the need for more intensive research prior to the initiation of any large scale reseeding program.

A report based on this study has been submitted for publication.

5. Other work in 1935

a. Plant vigor studies. The essential findings of the nutrition study has been completed in report form and submitted for publication. The field work on the clipping phase of this study was also completed. The ninth season of browse clipping has been completed and a report on this work is being prepared.

b. Natural revegetation. In addition to routine quadrat and plot work on this project, a number of temporary plots were located and estimated as a basis for providing further information on trends of natural revegetation.

c. Climate and plant growth. Climatic and phenological records were maintained at designated observation stations.

## Plans for 1936

1. A report will be completed summarizing the clipping phase of the plant vigor nutrition study.

2. Nine years of browse clipping data will be analyzed and summarized for publication.

3. An analysis will be made of the natural revegetation data and a report prepared on the progress of this project.

4. In addition to necessary routine work, effort will be directed to complete the following:

   a. The extension of the findings of the relationship of snow disappearance and plant development to the Manti National Forest to determine its practical value to a forest unit.

   b. The revision of the present utilization study. The first phase of this study has been completed and steps will be taken to initiate the second part.

   c. The completion of an intensive vegetation, erosion, and soil survey of Ephraim Canyon.

## MANAGEMENT SAGEBRUSH-WHEATGRASS RANGE

Spring-fall range investigations during the past year were concentrated on studies regarding the effect of drought on range productivity and management and range research methodology, as well as continuation of routine phases of paddock and open range studies at the U. S. Sheep Experiment Station near Dubois, Idaho. Following is a summary of the significant findings of these studies:

### 1. Management During Drought

The drought of 1934 not only was the most severe recorded at the U.S. Sheep Experiment Station, but was preceded by a period in which 13 of 16 years had subnormal precipitation. On ungrazed areas the principal forage, perennial bunchgrasses, was reduced 62 percent from density recorded in the slightly subnormal year, 1932. Although these grasses were seemingly greatly increased in vigor with return of favorable precipitation during the 1935 growing season, disintegration of large clumps and mortality of weakened individuals continued. At the end of the 1935 growing season, grasses had recovered only 14 percent of their 1934 losses.

Three systems of management permitted forage utilization during the drought without additional damage to perennial bunchgrasses. These were: (1) fall grazing with complete protection in the spring; (2) complete protection from spring grazing during the drought with late, moderate spring use the following year; and (3) moderately heavy early spring use (55-60 percent) in the drought year with complete protection of late and very light grazing (24 percent) the following spring.

Continuous spring grazing during the drought and subsequent year, or spring use heavier than 40 percent obtained in limited and annually rotated periods, reduced bunchgrasses up to 67 percent more than the density loss caused by drought alone.

To maintain bunchgrasses on this type of range during drought periods, spring grazing should be discontinued, either in the drought or the following year, or reduction in stocking for the two years, plus rotation of use should be practiced. In any event, provision for considerate use of drought stricken areas should extend not only to the drought year but to the year following where perpetuation of perennial bunchgrasses is desired.

### 2. Bunchgrass Utilization Accurately Determined

Measurements of forage utilization so necessary to efficient range management have yielded data open to criticism, owing to

inaccuracies and inherent personal error in methods by which obtained. That simple ocular estimates, if held to small plots (25 to 100 square feet) and adequately replicated, yield accurate measurement of utilization is brought out by a comparative study of methods of obtaining percentage utilization.

Studying utilization of one bunchgrass species on 100 small (5 feet by 5 feet) plots and using percentage of total forage weight removed by clipping for an absolute base, ocular methods were surprisingly accurate and free from personal error. Three estimators working independently without checking against weights, by viewing utilization of individual plants and averaging these estimates by plots, came within 5 percent of actual volume removed. When plot utilization was estimated as a blanket figure, the most experienced came within 1 percent of actual volume removal while a novice estimated 25 percent high. The novice's estimates of individual plots, however, followed closely the trend of volume removal. With frequent checks against weight of clipped herbage and with adequate plot replication, either of these methods if limited to small plots are sufficiently accurate and free from personal error to be of great utility in range investigations or management.

3. Susceptibility of Fine-Leaved Sagebrush to Fall Injury

Data from three sagebrush plants collected at the U. S. Sheep Experiment Station in November 1934, indicate why fine-leaved sagebrush (Artemisia tripartita) is more susceptible to injury from fall grazing or burning on sagebrush-wheatgrass range than are perennial bunchgrasses. Analyses by Dr. E. C. McCarty, collaborator with the Intermountain Forest and Range Experiment Station, reveal that in the autumn 57 percent of all reducing sugars, sucrose and starch is stored in current stem and leaf growth. Only 20 percent was stored in the roots, the remaining 23 percent being in main stems and secondary branches. In comparison, virtually 100 percent of the fall carbohydrate storage in bunchgrasses is in the roots and root crowns, since herbage is cured and physiologically inert from about July 15. Thus, with sagebrush storing more than half its food reserve for next season's growth in current twig and leaf production while grasses store virtually 100 percent under or near the soil surface, it is obvious that burning or heavy grazing in the fall may greatly impair sagebrush growth while causing minimum injury to cured grasses.

4. Season of Greatest Injury from Spring Grazing

Preliminary results from 2 years' clipping tests, 1934 and 1935, indicate the first 20 days of the spring grazing season (which commences after grasses reach 2-inch height) to be the period of greatest injury. The most severe breaking up of grass clumps and consequent loss of basal area occurred on plots clipped in this period. For Agropyron spicatum and Balsamorhiza sagittata, the least injury was apparent in the intermediate or second 20-day period. For Stipa comata the least injury occurred in the last or third 20-day spring period.

5. Period of Highest Plant Nutritive Value

Results from 3 years of systematic ewe weights at intervals during the spring grazing season, although not yet conclusive, indicate from consistent gains in body weight in the first 3 to 4 weeks of spring grazing that plant nutrition is highest during the period of early succulent growth. Grazing during the latter half of the spring season when forage is partially cured resulted in smaller gains and in some cases losses in ewe weight. No consistent variation in reactions of different sheep breeds to succulent or mature forage has yet been determined. More data are needed to substantiate definite conclusions.

6. Original Amount of Grass Influences Plot Reaction to Other Disturbances

Analysis of the average grass basal area change from 1932 to 1935 on 45 quadrats in 12 paddocks grazed to different intensities and at different dates during this drought period reveals that the original basal area stocking of a quadrat exerts as much or more influence on the end reaction than does the combination of drought and grazing effects. Grouping the grazed quadrats into classes ranging from 20 square centimeters to 420 square centimeters according to the total amount of grass basal area per quadrat in 1932, the 1935 basal areas assume a definite curvilinear aspect. Assuming that a curve fitted to the population is approximately correct then all grazed quadrats having 60 square centimeters of grasses in 1932 increased 152 percent by 1935 while those having 420 square centimeters decreased 88 percent. Readings from the curve to denote the curvilineer trend of grass basal area changes on grazed quadrats are tabulated below.

| Total Grass Basal Area (Square Centimeters) | |
|---|---|
| 1932 | 1935 |
| 60 | 151 |
| 120 | 96 |
| 180 | 68 |
| 240 | 56 |
| 300 | 52 |
| 360 | 51 |
| 420 | 50 |

Theoretically this trend, while surprising, is plausible. Areas undepleted and stocked to maximum with grasses are at delicate balance with climate and biotic influence. An unfavorable shift in this balance may cause disastrous effects, whereas, on lightly stocked, depleted areas still holding their soil fertility, these effects may be minimized or completely overcome by the spreading of plants to unoccupied space.

These results suggest why similar grazing systems sometimes give widely different results on areas essentially in climax condition than on areas 50 percent or more depleted.

7. Obtaining Current Forage Yield of Bluebunch Wheatgrass

Preliminary analysis of 1935 forage yield data on bluebunch wheatgrass shows that ten 20-plant plots had a mean yield of 60.95 grams with a standard deviation of 8.648 grams per plot. This indicates that plots containing 20 individual plants and replicated eight times will sample the wheatgrass population on a given area with a statistical error of 5 percent. Four such plots will sample yield within 7 percent error which is considered adequate for yield studies at the Sheep Station. Further statistical checks will be made during the 1936 season.

8. Soil Moisture Studies

Begun in 1935 soil moisture studies at the Sheep Station indicate that the trend of soil moisture is essentially the same throughout the growing season for the three layers sampled; namely, 0-6", 6"-12" and 12"-18". This, no doubt, is due to homogenous soil structure, to lack of drainage features and to the shallow soil depth. Basing available moisture on Briggs' and Shantz's formula $W.C. = \frac{M.E.}{1.84}$ soil moisture at all three depths became unavailable between June 4 and 5. Height growth of Agropyron spicatum and of Balsamorhiza sagittata ceased approximately June 10 and June 5. A high correlation (above +.59) was apparent between precipitation and amount of soil moisture at any depth.

Wind movement, humidity, temperature, and evaporation studies were carried on, but to date have yielded few results of direct application.

## Plans for 1936

1. Grazing studies during 1936 will be pointed toward the following objectives:

   a. Determination of the proper intensity of spring grazing.
   b. The effect of different systems of spring deferment and rotation on grazing capacity.
   c. The period of maximum susceptibility of range forage to injury from spring grazing.

2. Investigations of the accuracy and adequacy of yield and forage inventory sampling methods will be continued with the view to improving technique.

3. Climatological and phenological records will be continued as a basis for correlating climate with plant growth and behavior.

## MANAGEMENT DESERT SHRUB RANGES

The influence of climatic variations on various phases of desert shrub range management constituted the principal efforts at the Desert Range Branch during the past year, although the work program also included a survey of range conditions on the Red Desert of Wyoming. The important results of these efforts are outlined below.

### 1. Range Depletion on the Red Desert

A detailed survey of the Red Desert in Wyoming during 1935 revealed that 33 percent of the plant cover has been destroyed and grazing capacity reduced 56 percent on heavily grazed ranges, as compared to protected or semiprotected areas. Mortality counts show startling losses among the better forage species on heavily grazed ranges. For example, 51 percent of the ricegrass (Oryzopsis hymenoides), 31 percent white sage (Eurotia lanata), 39.8 percent budsage (Artemisia spinescens), and 20 percent of the Nuttall saltbrush (Atriplex nuttallii) have succumbed on the grazed ranges as compared with deaths of only 2, 11, 5, and 2 percent respectively on protected plots. Inferior forage species, such as desert rabbitbrush (Chrysothamnus spp.), snakeweed (Gutierrezia sarothrae), and Russian thistle (Salsola pestifer) have rapidly invaded the overgrazed and denuded ranges where they have increased a thousand fold.

The destruction of the stabilized native plant cover has not only curtailed forage production, but has exposed the dry desert soils to the winds which sweep the fine top soil into dense swirling clouds of dust. These dust storms have increased tremendously in frequency and intensity during the last two decades. Cattlemen, who once wintered and fattened large herds of cattle on the Red Desert of Wyoming, now lament that meager forage production precludes the possibility of cattle wintering on the open range.

The above findings are in direct controversy to a report on the Red Desert by a well-known botanist in which he states, "The vegetation in 1926 was, at least equal to that of 1897." This botanist also reports, "According to the most reliable sheepmen, the same areas that twenty years ago would only support one sheep will now better support from three to five." Thus, he makes the assumption that the ranges on the Red Desert increased 3 to 5 times in productivity during the period 1906 to 1926. In the survey here reported every stockman, herder, ranchman, or old time resident maintained that these ranges had deteriorated appreciably.

## 2. The Variability of Precipitation on Utah Desert Ranges

Precipitation on the semidesert ranges of western Utah is very sporadic and varies greatly from month to month and season to season. Rainfall at the desert range for the period June to October inclusive, was only .33 of an inch in 1933, but was 4.00 inches in 1935, a variation of more than 12 times. Summer storms are often localized and frequently occur as torrential downpours. For example, in 1935 the headquarters station received .66 of an inch precipitation in less than two hours from a storm less than 10 miles in width. Winter snowfall is somewhat more uniform but frequently one valley will receive 5 to 8 inches of snow while an adjacent one is dry and dusty.

The extent to which fluctuations of precipitation have a bearing on the growth and use of desert shrub range forage is shown by studies of various relationships outlined below.

## 3. Plant Growth as Influenced by Precipitation

The volume of current forage growth on desert shrubs may vary as much as 300 percent between dry and wet years, according to measurements that were made at and near the Desert Range Branch in 1934 and 1935. Moreover, as is shown in the following summary, equally wide variations in forage production may occur in the same year on comparable range areas within a radius of 20 miles. Observations on these same plants show also that good seed crops are produced only in years of favorable moisture.

The wide fluctuations in forage production from year to year and from one range area to another in the same year are not the only hazards involved in utilizing the desert winter ranges. Utilization is also dependent to a large extent upon water from snow, but snow water is not always available on areas where good supplies of forage have been produced during the year. From these relationships it is obvious that practical desert range management must be based upon allotments of sufficiently large range units to each herd so that adequate forage for a full grazing season can be obtained whether good growth occurs on all or on only part of the range area. These studies also indicate that facilities for hauling supplementary water are of value.

Table 1. The relative growth of two desert shrub and one grass forage species on representative Utah desert range areas in 1934 and 1935.

| | 1934 | 1935 |
|---|---|---|
| **WHITESAGE** | | |
| 1. Snake Valley | 3.12 | 7.67** |
| 2. Antelope Valley | 1.52 | 7.51** |
| 3. Headquarters | 2.49 | 7.16** |
| Average | 2.38 | 7.45 |
| **SHADSCALE** | | |
| 1. Snake Valley | 1.67 | 4.69 |
| 2. Antelope Valley | 1.46 | 6.53** |
| 3. Cedar Pass * | 5.31 | 14.34** |
| 4. Cedar Pass | 2.57 | 11.58** |
| 5. Headquarters | 3.85 | 7.43** |
| 6. Pine Valley | 3.55 | 6.96** |
| Average | 2.62 | 7.42 |
| **ORYZOPSIS** | | |
| 1. Pine Valley Pass | 7.03 | 14.36** |
| 2. Headquarters | 12.65 | 15.05** |
| Average | 9.84 | 14.70 |

* Flooded by run-off from summer rains, not included in the average
** Good seed crops

## 4. Variation in Plant Palatability

The palatability and utilization of desert range forage varies widely from year to year, presumably as the result of such factors as climatic conditions, composition of vegetation, growth, seasonal use, and differences in herds. Variations in palatability were found to be especially noticeable between wet and dry years, as is indicated in the following table, based on detailed observations of utilization of a number of major forage species on the winter range during the period 1932-1935.

Table 2. The relative palatability of principal forage species

| Species | 1932 | 1933 | 1934 | 1935 |
|---|---|---|---|---|
| Ricegrass (Oryzopsis hymenoides) | 95 | 95 | 85 | 90 |
| Curlygrass (Hilaria jamesii) | 35 | 35 | 40 | 70** |
| Dropseed (Sporobolus cryptandrus) | 10 | 10 | 15 | 15 |
| Blue grama (Bouteloua gracilis) | 5 | 5 | 10 | 10 |
| " " " " | 45 | 35 | 45 | 55* |
| Black sage (Artemisia nova) | 95 | 90 | 85 | 90 |
| White sage (Eurotia lanata) | 80 | 85 | 65 | 30** |
| Budsage (Artemisia spinescens) | 5 | 0 | 5 | 5 |
| " " " | 90 | 80 | 85 | 90* |
| Shadscale (Atriplex confertifolia) | 30 | 25 | 25 | 55** |
| Mormon tea (Ephedra nevadensis) | 65 | 50 | 70 | -- |
| Globemallow (Sphaeralcea grossulariaefolia) | 60 | 80 | 50 | 90 |

* Spring utilization values

** Species which show marked change in palatability during 1935 as compared with previous years.

Precipitation and growth during 1935 was greater than any year since 1931 and was more than twice that of 1934. Much of the precipitation occurred during the growing summer months. Such species as curlygrass, ricegrass and dropseed thrived throughout the summer, and consequently there was a predominating abundance of grass forage. The summer rains influenced the growth of shrubs to a lesser degree. White sage and shadscale, however, made good growth and produced an abundant seed crop, for the first time since 1931.

All of these factors appeared to have a bearing on palatability. For example, whereas white sage was reported to be highly palatable in the dry years of 1932, 1933, and 1934, it was found to be only 30 percent palatable on most areas during the past season, which was relatively wet. This species was particularly low in palatability on areas where there was an abundance of other kinds of forage, but where other forage occurred in limited amounts it was utilized to the extent of from 60 to 80 percent. The harsh woody stems which resulted from the more luxuriant growth of last summer appear to have been another important factor limiting the use of this species.

The unusual growth of shadscale during the past year is illustrative of another factor influencing palatability. For the first time in many years current growth extended $2\frac{1}{2}$ inches beyond the heavy armor of spines that are characteristic of this species, thus making forage readily accessible to sheep which had been available only in limited quantities in previous years of drought.

A somewhat similar relationship was observed with respect to curly grass. This species grew throughout the entire summer and made a yield of total forage many times greater than during previous seasons of drought and limited summer rains. Presumably as a consequence of this, the palatability of this grass increased approximately 100 percent.

These observations indicate some of the difficulties that are involved in compiling a standardized index of palatability for desert range plants and emphasize the need for continued observation of plant growth as a basis for developing sound management practices.

5. Maintaining Range Sheep on Desert Forage

The possibility of maintaining sheep in a thrifty condition on desert range forage without supplemental feeds is clearly illustrated in paddock studies made at the Desert Range Branch during the past year. Using representative animals in six paddocks for a period of 59 days average weights show rams gained .83 pounds per head, ewes gained 3.64 pounds and lambs 7.95 pounds.

These gains were made by utilizing approximately 47 percent of the available forage. Of the forage utilized 42 percent was shadscale, 26 percent curlygrass, 10 percent ricegrass, 8 percent white sage, 8 percent dropseed, and 6 percent budsage.

6. Revegetation as Influenced by Drought and Grazing

The density of desert range forage plants increased about 1 percent during the drought period, 1932-1935, when protected from grazing, whereas the density of similar plants on comparable but grazed range decreased approximately 17 percent in the same period, as measured on study plots near the Desert Range Branch.

Although the average increase in the density of all of the plants was small, it is of special interest that a relatively large increase in the density of palatable species occurred on protected areas as compared to increases of only unpalatable species on grazed areas. Such valuable species as ricegrass and whitesage made especially significant gains in density when protected from grazing. Shadscale and budsage, also valuable range plants, failed to improve under protection from grazing, however, both species having declined in density during the drought period on protected areas as well as on grazed range. Rabbitbrush, an unpalatable species, increased in frequency only on grazed areas.

These observations obviously suggest that rehabilitation of depleted winter ranges can be accomplished by natural revegetation when adequate protection is given to the most desirable range plants. The studies have not progressed over a long enough period of years to determine the rate of recovery that may be expected nor have other phases of research now under way revealed the extent to which these plants can be grazed without seriously affecting range recovery.

## Plans for 1936

1. Continue routine phases of the grazing plan for the Desert Range Branch paddock and range areas that were initiated in 1934.

2. Continue climatological and phenological measurements.

3. Continue palatability and utilization studies.

4. Continue natural revegetation studies, including ecological correlations of desert vegetation and soil relationships.

5. Continue cooperative nutrition studies with the Utah State Agricultural College.

## ARTIFICIAL RESEEDING

A new project on artificial reseeding on range and watershed lands is in the process of getting under way on funds recently made available for that purpose. During the winter the necessary cooperative agreements and understandings have been completed, some actual planting has been done, and a start made on general survey of considerable scope which is essential to the proper planning and conduct of the investigations. Some of the major factors being given consideration in planning this work and a brief outline of the character of work to be done in 1936 follows:

### 1. Grasses Require Productive Soils

Experimental data from Philadelphia Flat in Ephraim Canyon in central Utah show that on areas where the soils are productive, grasses have become successfully established after reseeding but have failed almost completely where the top soil layer rich in organic material has been removed. The presence of water at the south end of the flat has for many years exposed most of the area to heavy grazing. Dust storms have carried away nearly all the top soils from heavily grazed areas.

In spite of several reseedings on parts of the flat, no grasses at all are found except in three small areas. One of these, in a cove protected from wind action, bears a magnificent stand of Kentucky blue grass. Another small area somewhat protected bears from one-third to one-half of a grass stand, and a third area about a mile to the north has the original native grass stand in good condition. All the remainder of the flat bears either annual or perennial weeds, with scarcely any grass, even in small bunches.

Soil analyses shown in table 1 explain the presence of grass in some places and its entire absence in others. Success in establishing new grass stands or in maintaining old ones is clearly dependent on good soils.

### 2. Nature of Effort will Vary with Quality of Soil

On large parts of the range country where the soils are moderately good, plants will revegetate themselves if given a respite from heavy and untimely grazing, from fire, from accelerated erosion, and from uncontrolled use during drought. The Forest Service has found, during 30 years of administrative experience and 10 to 15 years of research, the sort of range management that is required to bring about active revegetation. This part of the restoration program can be started at once so far as knowledge of how to do it is concerned.

On other large parts of the range country, key forage species have disappeared from large areas and natural recovery even under good range management practice will probably take a generation or longer. Also, on many millions of acres so much of the productive top soil has been stripped away that the valuable original plants cannot survive, owing to the lack of plant nutrients or to the inability of such soils to hold the needed moisture. Where revegetation is difficult, and on critical areas where for one reason or another natural processes cannot be waited for, it is necessary to undertake the reseeding of such lands with plant varieties that have a reasonable chance of success.

Table 1. Condition of vegetation and forage production on reseeded areas with good and poor soils. Philadelphia Flat.

| Vegetation Present | Soil Notes | Organic Matter % | Total Nitrogen % | Forage Production |
|---|---|---|---|---|
| 1. Good stand Ky. bluegrass | Dark original soil present | 9.7 | 0.60 | Abundant |
| 2. Mixed bluegrass, wheatgrass & weeds | Part of dark soil present | 7.1 | 0.40 | Fair |
| 3. Undisturbed native grass cover | Dark original soil present - original grass also present | 8.9 | 0.47 | Good |
| 4. Weeds only | Raw clay subsoil - Top soil all removed | 3.6 | 0.21 | Poor |
| 5. Weeds only | do. | 3.1 | 0.17 | Poor |
| 6. Bromus inermis | do. | 4.1 | 0.24 | Medium |
| 7. Weeds only near #1 but with top soil gone | do. | 3.1 | 0.20 | Poor |

3. Study of Plant Varieties Needed

In the first place the soils must be classified as to the amount and kind of vegetation they can support. The next step is a thorough canvass for plants suitable to each soil condition. Since, for these problems even the basic information is lacking, incisive fundamental research is required. Up to the present, attempts at reseeding have been limited almost entirely on good soils and largely to three or four well-known forage plants, such as common smooth bromegrass, the native western wheatgrass, and crested wheatgrass, the last an immigrant from the steppes of the Caspian Sea. As none of these take hold on poor shallow soils new plants must be sought. Every exploring party into central Asia should have attached to it a range man whose duty it is to gather seeds of promising range plants.

4. Place of Plant Breeding

Any one species of forage plant usually possesses several good qualities but lacks one or more desirable qualities that another species may have. The solution of this difficulty probably lies in an effort to manufacture by breeding a new plant that will meet the need. In order to unite in one variety the desirable qualities from several parental forms, crossing is necessary. In the Intermountain region one cross that should be attempted is between the large palatable native mountain brome (Bromus carinatus) and the aggressive but short season imported cheatgrass (Bromus tectorum). However, this plant is edible for only a few weeks. Could its ability to spread and grow on poor soils be united with the fresh, long season growth of mountain brome, a valuable hybrid might result. However, we must face squarely that any single attempt may prove unsuccessful. Nevertheless, on the whole the vast number of successes achieved in cultivated agriculture from importations and from plant breeding makes it seem likely that a thorough effort may yield important results. This will be a long and difficult task, but one that should not be abandoned on that account.

5. Cooperation

The plant breeding phases of this project is being undertaken in cooperation with the Bureau of Plant Industry. Other specific problems that require nursery and greenhouse studies are to be conducted in cooperation with the Bureau of Plant Industry and the Utah Agricultural Experiment Station.

## Plans for 1936

It is deemed necessary to explore rather thoroughly six phases of research connected with solving the problems that arise from the need for reseeding range and watershed lands. These problems and the character of work planned for 1936 include:

1. Develop a rough classification of soils into four or more groups according to quality.

2. Correlate the general adaptation of various plant groups to soils of different quality.

3. Search for new plant varieties from native species, from importations, and from plant breeding productions.

4. Initiate tests to determine satisfactory seeding methods that will not cost more than the land can bear.

5. Conduct germination studies and explore seed supplies.

6. Select and develop trial centers for conducting various phases of investigational work.

SUPPLEMENT TO THE ANNUAL REPORT

1935 - 1936

PUBLICATIONS

Following is the status of publications at the Intermountain Forest and Range Experiment Station.

IN PRINT

Erosion-Streamflow Investigations

Bailey, R. W. - Shackling the mountain flood. American Forests, March 1935.

_____ - Epicycles of erosion in the valleys of the Colorado Plateau Province. Jour. Geology, July 1935.

Craddock, G. W. and Pearse, C. K. - Uncle Sam goes into the rainmaking business. Idaho Statesman Sunday Supplement, Feb. 1936.

Croft, A. R. - Watersheds and the farmer. The Utah Farmer, Oct. 1935.

Pearse, C. K. - An area list method of measuring range plant populations. Ecology XVI, 1935.

_____ - Specifications for the construction and operation of a portable apparatus for measuring surficial run-off and erosion. Mimeographed Report. March 1936.

_____ - Pechanec, Jos. F. and Pickford, G. D. - An improved pantograph for mapping vegetation. Ecology XVI, 1935.

Connaughton, C. A. - Fire damage in the ponderosa pine type in Idaho. Jour. Forestry, Vol. XXXIV. 1936.

_____ -Forest fires and accelerated erosion. Jour. Forestry, Vol. XXXIII, No. 8, August 1935.

_____ - Growth in virgin ponderosa pine stands in central Idaho. Jour. For. Vol. XXXIII No. 1., Jan. 1935.

_____ - The accumulation and rate of melting of snow as influenced by vegetation. Jour. For., Vol. XXXIII, No. 6, 1935.

_____ - Forests catch less snow than bare ground but are superior in regulating melting. Bul. Am. Meteor. Soc. 17: 48-49, 1936.

Range Management Investigations

Forsling, C. L. and Stewart, Geo. - Proceedings of World Grain Exhibition and Conference. Canada, 1933. Vol. II, pp. 177-182. Published 1935.

Pechanec J. P. - Comments on the "stem count" method of determining percentage utilization. Ecology, April 1936.

Pickford, G. D. and Stewart, Geo. - Coordinate method of mapping low shrubs. Ecology, April 1935, pp. 257-261.

Stewart, George - Plant cover and forage conditions on spring-fall and winter ranges, largely on public domain lands in the intermountain region. Utah Juniper 6: 9-13, 1935.

_____ - A tentative recommendation of technic for grazing experiments on range pastures in arid or semi-arid regions. Jour. Amer. Soc. Agron. 27: 1018-1019, 1935.

SUBMITTED FOR PUBLICATION

Erosion-Streamflow Investigations

Renner, F. G. - Erosion on the Boise River watershed as affected by various physiographic and biotic factors. (USDA Misc. Pub.)

Forest Management (Silvical Research)

Connaughton, C. A.- Logging with motor trucks in central Idaho. (American Lumberman)

Range Management Investigations

Pechanec, J. F. - The identification of grasses of the upper Snake River plains by their vegetative characters. (Ecology).

Stewart, George and Keller, Wesley - A correlation method for Ecology as exemplified by native desert vegetation. (Ecology)

_____ -Cottam, W. P. and Hutchings, S. S. - Plant associations in desert valleys of western Utah and forage conditions as influenced by unrestricted grazing. (To be forwarded from W. O.)

MANUSCRIPTS TO BE SUBMITTED DURING CALENDAR YEAR

A. USDA PUBLICATIONS

Erosion-Streamflow Investigations

Craddock, G. W. and Pearse C. K. - The influence of plant cover, degree slope, soil condition, and rainfall intensity on run-off and erosion from granitic soils in Idaho (J.A.R. or Misc. Pub, 15 to 25 pages, 6 to 8 illustrations).

Range Management Investigations

Craddock, G. W., Forsling, C. L., Denecke, W. A., and Cooper, J. M. - The influence of climate and grazing on spring-fall range lands in relation to range sheep production in south eastern Idaho. (Tech. Bul. probably 30-40 pages)

Costello, D. F. and Price, Raymond - Climate and plant development in relation to range management. (For.F.A.R., 15-20 pages.)

Hutchings, S. S. and Stahmann, Ben R. - Utilization and palatability of desert vegetation as influenced by climate and plant cover. (Probably Misc. Publication, 25-35 pages.)

McCarty, E. C.- The growth and annual march of the carbohydrates in the many-flowered bromegrass (Bromus polyanthus). (For J.A.R., probably 20-30 pages, illustrated.)

_____, and Price, Raymond. Influence of season and frequency of clipping on carbohydrate metabolism of Agropyron pauciflorum, Bromus carinatus, and Geranium viscosissimum. (Tech. or Misc. Publication, probably 20-30 pages, illus.)

Stewart, George, Pickford, G. D., and Hutchings, S. S. - Influence of past grazing on the open spring-fall and winter ranges of the Intermountain region. (Technical bulletin, probably 100 pages.)

B. FOR OTHER PUBLICATIONS

Erosion-Streamflow Investigations

Bailey, R. W. - Geologic factors and relationships in the problem of accelerated erosion and floods. (Article)

_____ - Origin of mud flows (Article)

_____ - What is accelerated erosion (Article)

_____ and Croft, A. R. - Watershed-valley relationships in the Bonneville Basin. (Article)

_____ and Owen, J. Wallace - Erosion terminology (Article)

Craddock, G. W. - Bunchgrass in relation to run-off and erosion (Article)

Croft, A. R. - Watershed values in Utah (Article)

Daniels, K. M.- An analysis of snow survey technique (Article)

Hill, L. K. - A combination Venturi flume - trapezoidal weir for measuring debris laden streamflow on steep slopes. (Article)

Pearse, C. K. - A new technique in the study of erosion streamflow problems (Article)

_____, and Woolley, S. B. - The influence of plant cover on the rate of absorption of surface water by soils. (Article)

Spence, L. E. - Root systems of important range plants of the Boise River watershed. (Article)

Forest Management (Silvical Research)

Mowat, E. L. - The results of part cutting practice in the ponderosa pine forests of central Idaho. (Mimeo. Report and Article)

_____ - Damage to reproduction by caterpillar logging (Article)

_____ - Trends of volatile content of evergreen foliage during periods of drought stress. (Article)

_____ - The effect of slope on maximum soil temperature (Article)

Range Management Investigations

Cottam, W. P. and Plummer, Perry - Morphology of vascular rings in desert shrubs in relation to age of plants. (Article)

_____ and Stewart, George - Plant succession as a result of meadow desiccation at Mountain Meadows, Utah, since settlement (1862). (Article)

Griswold, Sylvia M. - Effect of alternate moistening and drying on the germination of seeds (Article)

Harris, J. A. and Stewart, George - Plant sap studies as related to ecological sites and influences in the Bonneville Basin, Utah (Article)

Hutchings, S. S. and Stahmann, Ben R. - Methods of estimating utilization of desert forage species (Article)

_____ and Stahmann, Ben R. - Plant mortality and age classes of desert species on protected and grazed ranges of central Nevada (Article)

_____ and Stewart, George - Making a forage inventory on desert shrub plant associations (Article)

Pechanec, J. F. and Pickford, G. D. - A comparison of some methods used in determining percentage utilization of grasses (Article)

Pickford, G. D., Pechanec, J. F., and Stewart, George - Immediate and subsequent effects of 1934 drought on native vegetation of Snake River plains, Idaho (Article)

Price, Raymond - The results of artificial reseeding trials on an oakbrush range (Article)

_____ - Influence of closeness of clipping on vigor and productivity of some summer range plants (Article)

_____ and Evans, Robert B. - Climate of the west front of the Wasatch Plateau in central Utah (Article)

Stewart, George - Relation of soil profile and the quality of soils to vegetation and to erosion on the Boise and Sawtooth Forests (Article)

_____ - Size, shape and frequency of plots for range survey (Article)

_____, Clark, Ira, and Stahmann, Ben R. - Comparative plant cover and forage conditions on open ranges and on railroad right-of-way in central Nevada (Article)

_____ - Studies in desert soils. (Article)

_____ and Hutchings, S. S. - The square-foot density, or point observation, plot method of estimating plant cover (Article)

_____, Pickford, G. D. and Pechanec, J. F. - Effect of controlled burning on spring-fall range in southeastern Idaho (Article)

## PROPOSALS FOR NEW WORK

## COOPERATIVE STUDIES AND NATURAL AREAS

At the present time the station program is seriously handicapped by a lack of regular funds for conducting going projects on an effective basis. Notwithstanding this deficiency, the station program should be expanded by 1938 insofar as new funds permit, to include erosion-streamflow studies in the grasslands and open brush and forest areas of the Colorado River drainage and in the ponderosa pine forest of southern Idaho, and silvicultural studies of lodgepole pine. In addition, the present forest management investigation should be broadened to include an intensive study of the fire problem in Region 4. Statements concerning these proposed efforts and brief comments on cooperative work and natural areas follow.

### EROSION-STREAMFLOW

1. Colorado River Studies

Study of the influence of range and forest plant cover on streamflow and erosion in the Colorado River drainage is urgently needed as a basis for proper management of the resources of this vast and important watershed. Already approximately 500 million dollars have been invested in developments along this river to make use of the streamflow both within and outside of the drainage basin, and plans have been suggested for expending an equal amount on additional and similar improvements for power, irrigation, domestic, and flood control purposes.

These and other developments, however, are being seriously threatened by accelerated erosion over extensive portions of the watershed, which is contributing enormous quantities of silt to the stream channel and which is reducing the fertility of the soil for range forage production purposes. Thus, not only is the usefulness of the water development structures being impaired, but the range livestock industry which is dependent upon range forage, is also being jeopardized.

The headwaters of most of the tributaries in this drainage basin originate on national forests, definitely placing the responsibility with the Forest Service for maintaining proper cover conditions on the watersheds for protection purposes. The limited information now at hand concerning proper management practices and rehabilitation measures for these lands clearly justifies the need for initiating influence studies in the immediate future.

On the basis of preliminary observations, suitable experimental watersheds have been found for conducting studies on this area.

2. Ponderosa Pine Studies

Influence studies in the ponderosa pine forest of southern Idaho are needed to supplement present studies on grassland areas in that locality. The ponderosa pine forests in addition to being the most valuable source of timber in the region, contributes much of the water for domestic and agricultural purposes in the lower Snake River Valley. In recent years, acute water shortages during the irrigation season have caused water users to question the advisability of cutting timber on the watersheds. The situation has become especially acute in Boise Valley where water shortages, due to inadequate flow of Boise River, have occurred in 9 of the past 12 years, resulting in crop losses averaging about $2,000,000 annually. The people in this locality are keenly aware of the relationship between adjacent watershed lands and their valley property, and are actively urging that the Forest Service expand its watershed studies to include work in the ponderosa pine type.

Preliminary observations indicate that suitable areas for conducting ponderosa pine influence studies are within easy reach of the Boise Basin Branch Station, near Idaho City, Idaho. CCC help is also available at this area for construction purposes.

FOREST MANAGEMENT

1. Lodgepole Pine Studies

Study of lodgepole pine silviculture is vital to Region 4. At the present time a large share of the timber sale receipts in this region are derived from this forest type and many acres are being cut over annually. The lack of silvical knowledge as applied to lodgepole pine, particularly where it is growing in mixed stands, is well known. Future demands on the lodgepole pine type to furnish forest products are likely to be great and, therefore, a basis of management should be prepared on round principles developed by research. CCC camps are now located in the lodgepole pine type and local forest officers are continually seeking advice concerning proper methods of cutting this species. The station can do little toward assisting on these problems in the lodgepole pine type under the present circumstances--but in view of the importance of this work, provision should be made for starting this project by 1938 at least.

The latest expression of interest along this line was encountered at the recent investigative meeting when the entire group offered to go on record in favor of immediate expansion of silvical investigations to include the lodgepole pine type.

Suitable areas for conducting studies on this project have been explored in a preliminary manner.

2. Fire Studies

The expansion of the branch of silvicultural investigations to provide for personnel to conduct fire studies is very much desired by the Regional Office. During the past four years the Regional Office has made some excellent administrative studies along this line. They have now evolved several new principles and ideas, and have laid the ground work for more intensive studies which they desire the branch of research to conduct.

The importance of these studies is obvious to anyone who knows the fire situation in this region and who has followed the progress made thus far by fire studies. Cooperative assistance both in personnel and funds can be obtained from the Regional Office if the station will provide a man to organize and direct the work. It is estimated this work can be handled effectively by the station with an allotment of $5,000 annually.

3. Tree Physiology

Provision for physiological research pertaining to forest trees should be kept in mind and expansion in this direction hastened as much as possible. The urgency of this type of work is not so pronounced as the need for lodgepole pine and fire studies, but the far reaching possibilities to be derived from physiological studies should not be underestimated.

SUGGESTIONS FOR COOPERATIVE WORK

1. Rodent Studies

Rodent studies should be expanded in this region to include more intensive work on the national forests. Rodents play an important part in many phases of management and research on national forest and other wild lands in this region but thus far the program of work in this field has been inadequate. Rodent activity has been found to be definitely correlated with accelerated erosion on certain portions of the Boise River watershed in southern Idaho, and are recognized as being a contributing factor to range depletion and accelerated erosion on some parts of national forests in Utah. Although this problem is being attacked on several fronts by branches of the Biological Survey and other organizations, it is felt more effective work can be accomplished on the national forest lands by assigning a corps of workers from the Biological Survey to the Forest Service. It is estimated that the assignment of one man for work in southern Idaho and one for Utah would be satisfactory for coping with this problem.

2. Fire Weather Studies

Fire weather studies in cooperation with the Weather Bureau should be expanded sufficiently to provide for the assignment of one man for work exclusively in this region. At the present time fire weather studies are being handled as a joint effort between Regions 4, 1, and 6. Although this recent arrangement has been of material assistance in meeting the fire problem in all of the regions involved, much greater benefits could be derived by assigning a full time man to this region.

General climatological records obtained at high elevations on the national forests are also urgently needed for coordinating range management practices on and the use of streamflow from watershed lands. The importance of water derived from the mountainous range watershed lands to the demands of communities in the semidesert valleys of this region has been generally recognized, but thus far provision for obtaining significant climatological records on these lands has been woefully inadequate. Engineers recognize that most of the failure of engineering developments such as roads, bridges, reclamation projects, power plants, etc., has been due to a lack of climatological information from which rational safety factors could be derived for planning purposes. The Forest Service has already established numerous yearlong and seasonal weather stations and snow courses at strategic points on the national forests and experimental areas. Additional records are needed and all should be coordinated and correlated with regular, established Weather Bureau records taken at the lower elevations. It is estimated an assignment of three full time men to the Forest Service could handle the climatological studies including fire weather studies, and provide a valuable basis for all phases of wild land management policies.

NATURAL AREAS

No concerted action has been taken toward establishing natural areas in this region since 1933. At that time, recommendations were submitted to the Forester for establishing four natural and one experimental range areas in Utah, including the following:

1. Diamond Fork Natural Range Area
   Uinta N. F., Utah.
   10-acre area of oakbrush range.

2. Joes Valley Natural Range Area
   Manti N. F., Utah
   10-acre area of pinyon-juniper-sagebrush range.

3. Tony Grove Natural Range Area
   Cache N. F., Utah
   6-acre area of aspen-grass-weed range.

4. Kanosh Natural Range Area
   Fishlake N. F., Utah
   10-acre area of oakbrush-pinyon-juniper range.

5. Mill Creek Browse Experimental Range
   Dixie N. F., Utah
   179 acres of mixed brush range.

None of these areas were approved because they were considered to be too small for the purposes designated. It was pointed out, however, that the Mill Creek browse area, while too small for experimental range purposes, was probably satisfactory for a natural area. The faulty description of the Mill Creek area has been corrected and consequently the report on this unit should be ready for approval and the area definitely designated as a natural area.

It is questioned whether range areas of more than 100 acres can be located in this region which are in virgin or even nearly virgin condition as prospective sites for natural areas. It was for this reason that original proposals included small tracts of land, although it is fully appreciated that more acreage is essential for meeting the requirements of true natural areas. In this connection, it is quite possible that the four original range units listed above may be enlarged to include enough acreage for natural area purposes.

No natural areas have been selected in southern Idaho although several tracts of 1,000 acres or more each in the ponderosa pine type have been given consideration.

Little difficulty is anticipated with respect to acquisition phases of the natural area program in this region, providing the acreage of the units set aside is held to a minimum.

## WORK CENTERS

Research at the Intermountain Forest and Range Experiment Station is concentrated at or near five branch experiment stations. The availability of emergency funds in recent years has made possible a material expansion and improvement in the facilities for research at these stations, although additional improvements are still needed to make each physical plant most effective. The following summaries indicate the status of these stations and the most pressing needs for each:

### 1. BOISE BASIN BRANCH EXPERIMENT STATION

Situated near Idaho City, Idaho this station was established in 1933 for the purpose of conducting silvicultural studies in the ponderosa pine type and erosion and streamflow investigations on the granitic soils of grassland ranges of the Boise River watershed.

#### Headquarters

The headquarters developments at this station now include two dwellings and double garages, one caretaker-mess house, bunkhouse, office, shop-storeroom, cold storage house, and woodshed, as well as one complete climatic station. Modern lighting, telephone, water and sewage systems are available, as well as service roads.

No additional buildings are needed at the present time, but provision should be made for enlarging the office and for developing a more nearly adequate water supply system for fire protection and irrigation purposes.

#### Research Facilities

Research at this station is concentrated on a nearly experimental forest and on other, more remote areas.

#### A. Boise Basin Experimental Forest

Situated about 6 miles from the branch headquarters, this experimental forest was approved on June 6, 1933 and has been used since then for intensive silvicultural studies of ponderosa pine and erosion and streamflow investigations. This area includes a total of 5,292 acres of former national forest land of which 2,182 acres is in virgin ponderosa pine, 1,847 acres in cut-over ponderosa pine, 244 acres in virgin Douglas fir, 31 acres in cut-over Douglas fir, and 988 acres of unmerchantable timber, brush and grass.

Developments on the area include about 6 miles of service road, 4 miles of telephone line, a shelter cabin, a woodshed, two 11-acre range watersheds equipped with devices for measuring precipitation and run-off and erosion, a battery of six 2-milacre steel lysimeters for measuring run-off and seepage from 4-foot soil profiles, one complete physical factor station and an experimental nursery.

Additional developments needed on this area include about 6 miles of utilization roads, 5 miles of fire line, water development for the shelter cabin, and a phytometer installation to supplement the present battery of lysimeters. It is expected that these improvements will be obtained during the year through allotments of emergency workers.

A young growth experimental forest in ponderosa pine is also needed to complete the requirements for silvicultural studies at this station. Such an area, including about 1,000 acres of land adjoining the Boise Basin Branch Experiment Station headquarters has been selected for this purpose and negotiations are now under way for including it in the experiment station tract.

B. Boise National Forest (Work Center)

In addition to intensive studies in the immediate vicinity of the Boise Basin Branch Experiment Station, erosion-streamflow and range investigations are conducted on a number of work centers situated on the Boise National Forest. Twelve enclosures of from 2 to 200 acres each have been fenced on range areas within the watershed on which detailed observations are made in connection with natural revegetation studies.

Additional facilities most urgently needed for intensifying erosion-streamflow and artificial reseeding studies on the range portion of this watershed work center include a substation for housing 1 yearlong worker and 3 or 4 seasonal workers, and technical facilities for conducting range-erosion studies on watersheds, pastures, and plots. On the basis of detailed inspections of 72 watersheds in the vicinity of Arrowrock Dam, suitable areas for these purposes have been located and plans outlined for proceeding with developments during the current year. These developments it is hoped will be handled largely as an emergency work project in cooperation with the Boise Forest.

2. WASATCH BRANCH EXPERIMENT STATION

Situated on the Wasatch Forest near Bountiful, Utah this station was established in 1934 for the purpose of conducting erosion and streamflow and range studies on the steep, herbaceous and brush-covered watershed lands typical of the Wasatch front.

## Headquarters

Headquarters developments at this station include one combination shelter cabin-office, a telephone line and service roads.

Additional improvements contemplated for this station include two shelter cabins, a caretaker-recorder dwelling, a bunkhouse, a field office-laboratory, a project leader dwelling, and two garages. It is planned to complete part of these improvements during the current year with allotments of emergency workers.

## Research Facilities

Research at this station is concentrated at three work centers in the vicinity of the headquarters, none of which have been withdrawn exclusively for research purposes as yet, pending the outcome of acquisition proceedings now under way.

### A. Parrish Creek Study Area

Situated at an elevation of about 8,000 feet, work on this area since 1934 has involved studies of erosion control by the terrace-trench, artificial reseeding, and natural revegetation methods, and of range plant influences on run-off and erosion by the permanent plot method.

Present facilities for these studies include twelve 1/40-acre and four 1/10-acre run-off plots, and one complete physical factor station in connection with 100 standard rain gages.

Needed improvements to perfect the facilities on this work center include a battery of interception pans and phytometers for water cycle studies, fences for protecting study areas and installations, and miscellaneous field laboratory equipment. Arrangements are under way for accomplishing much of this work during the current year.

### B. Farmington Canyon Experimental Watersheds

Seven tributaries of Farmington Canyon characterized by steep slopes and mixed timber, brush and herbaceous plant cover and ranging in size from about 40 to 140 acres were selected in 1935 for water yield and other aspects of erosion-streamflow studies. Present developments include three streamflow gaging stations, one complete physical factor station and about 2 miles of trail.

Improvements planned for the current year on these areas include the installation of improved streamflow measuring structures, debris basins and additional rain gaging stations; and the construction of service roads and trails for making all areas readily accessible, a shelter cabin, and a telephone system. All arrangements have been completed for proceeding with this work, pending the consummation of land purchases now under way in connection with the Wasatch Forest acquisition program.

C. Lime Canyon Experimental Watersheds

Six watersheds typical of foothill lands of the Wasatch front, ranging in size from 3 to 20 acres each and adjoining areas near Lime Canyon in the vicinity of Salt Lake City, Utah were selected in 1935 for run-off and erosion and range studies.

Since these lands are involved in the Wasatch Forest purchase program no physical improvements have been made on the areas as yet. Plans have been perfected, however, for intensive developments during the current year with emergency help. The major items contemplated in this connection include installation of run-off and erosion measuring devices on six watersheds and a complete physical factor station, the construction of a shelter cabin, fences and service roads, and the development of sample areas for artificial reseeding trails for erosion control and range rehabilitation purposes.

3. GREAT BASIN BRANCH EXPERIMENT STATION

Situated near Ephrain, Utah this station was established in 1912 for the purpose of conducting range and erosion-streamflow studies on summer range lands typical of the Wasatch Plateau.

Headquarters

The headquarters developments at this station now include three dwellings, two garages, and one mess house, office and laboratory, barn and shop. Modern telephone, power, water and sewage systems are available as well as service roads.

Improvements needed at headquarters include a dwelling, a bunkhouse, a temporary dwelling, a new office-laboratory, a complete underground water sprinkling system and a new 3-car garage. Arrangements have been made for proceeding with part of this work with emergency funds and labor -- both CCC and ERA.

Research Facilities

Present facilities for range and erosion-streamflow studies at or near the headquarters station include the following:

11 Fenced areas ranging in size from 1/4 to 42 acres for artificial reseeding studies.

6 Paddocks of from 8 to 80 acres and more than 1,000 small plots for natural revegetation studies.

9 Phenological stations for plant growth observations and four rodent-proof enclosures.

4 Physical factor stations for climatological phases of range and watershed studies.

2 10-acre watersheds and six 1/15-acre run-off plots equipped with streamflow gages and debris basins for run-off and erosion studies.

The most urgently needed improvement needed in connection with research facilities is a battery of sixteen 40-acre paddocks for intensive utilization studies.

## 4. DESERT RANGE BRANCH EXPERIMENT STATION

Situated approximately 50 miles west of Milford, Utah this station was established in 1933 by presidential proclamation for the purpose of conducting intensive studies of range management on winter ranges typical of the desert lands in the Great Basin. Research under way at this station includes investigations of climate and plant growth relationships and studies of palatability and utilization.

### Headquarters

Developments at the headquarters of this station include two dwellings, one combination mess-bunkhouse, an office-laboratory, a barn, a shop and tool house and a gasoline and oil house. Water is provided by means of a deep well and a 40,000-gallon reservoir, light is generated by a power plant, and communication facilities include a radio receiving and sending set, a telephone system, and roads.

Following is a list of improvements needed to complete the physical development of the Desert Range Branch headquarters, the conversion of 16 miles of grounded telephone line to a metallic circuit to eliminate noise and hum picked up from power line, sprinkling system for lawns, 9 miles of additional pasture fences, corrals, visitors' quarters, two duplex cottages for temporary field assistants, and a few small miscellaneous range improvements such as stock water holes, fence panels, etc.

## Experimental Facilities

Research facilities at this station include a 55,000-acre range area under fence, subdivided into sixteen 320-acre pastures, eleven 4-acre enclosures, thirty-two 1-acre enclosures and 1 nursery plot. One complete physical factor station is maintained at headquarters and 8 additional rain gages are located at distant points on the range. It is planned to set aside additional areas for artificial reseeding studies.

## 5. U. S. SHEEP EXPERIMENT STATION

Situated near Dubois, Idaho this station was established in 1914 by the U. S. Bureau of Animal Industry as a sheep breeding station. Since 1923 the U. S. Bureau of Animal Industry entered into a cooperative program of range management research studies with the U. S. Forest Service. This program has been continued to date as a basis for developing improved methods of range management for sagebrush-wheatgrass range lands.

## Headquarters

The physical development at this cooperative station headquarters include one dwelling and a combination garage-woodshed. Other facilities are placed at the disposal of the research workers by the cooperating bureau including water, light, telephone, and a bunkhouse.

Developments most urgently needed at this work center include a bunkhouse, a combination office and field laboratory and additional garage space.

## Research Facilities

Facilities for research work at this station include seventeen 80-acre paddocks for controlled grazing tests, a 23,000-acre herded range area, sheep in varying numbers for grazing trials, and a complete physical factor station. Sites for artificial reseeding studies have also been selected and trials initiated.

## MAINTENANCE NEEDS

Following is a brief itemization of maintenance needs for the various branch stations:

| | Caretaker-Recorder | Buildings, Fences, other improvements | Installations | Total |
|---|---|---|---|---|
| 1. Boise Basin Branch | 2,000 | 400 | 100 | 2,500 |
| 2. Wasatch Branch | 2,000 | 200 | 100 | 2,300 |
| 3. Great Basin Branch | 1,000 | 850 | 50 | 1,900 |
| 4. Desert Range Branch | 2,000 | 600 | - | 2,600 |
| 5. U.S. Sheep Exp. Sta. | - | 50 | - | 50 |
| | $7,000 | 2,100 | 250 | $9,350 |

# SUMMARY OF

# EROSION-STREAMFLOW

# PROJECTS

RR - INT
Erosion-Streamflow
Bunchgrass-Granitic Soils

## SUMMARY OF EROSION-STREAMFLOW PROJECTS

Project: The influence of plant cover and its use in the bunchgrass type on granitic soils on erosion and streamflow.

Character and Scope: To determine for watersheds of the bunchgrass type on loose granitic soils (1) the causes of erosion; (2) the rate of erosion; (3) the influence of herbaceous cover as affected by grazing use in controlling erosion and regulating run-off; and (4) methods of checking and controlling erosion and maintaining desirable run-off conditions by natural and artificial revegetation and other means. The problem involves the investigation of all the factors, especially those in which plant cover plays a part, that affect the yield and rate of discharge of water from a watershed and the erosion of the soil as a means of determining the amount, kind and regulation of cover that will obtain satisfactory streamflow and erosion control.

Progress:

1. The causes of accelerated erosion on the Boise River watershed as determined by an intensive survey in 1930 have been found to be correlated with overgrazing and other physical and biotic factors.

2. Studies of the rate of erosion are being conducted on a series of profile plots but no significant changes have been observed on these areas as yet.

3. Studies of the influence of plant cover on run-off and erosion by means of portable apparatus have revealed that the original bunchgrasses and other perennial plants having dense fibrous root systems are many times more effective for controlling erosion and for inducing absorption of water into the soil than taproot species now commonly found on overgrazed areas. Lysimeter and watershed installations have been completed for studying other phases of run-off and erosion relationships.

4. Preliminary efforts on erosion control methods have indicated the measures which offer most promise for rehabilitating eroding range lands and these data are to be used as a basis for proceeding with erosion control studies during the current year.

Plans: In addition to a continuation of studies on run-off and erosion relationships as influenced by plant cover, investigations during the current year are to include intensive efforts on erosion control work. Suitable range watersheds have been selected for this purpose and cooperative arrangements made for proceeding with this work.

Assignment: George W. Craddock and C. K. Pearse

Date of Completion: Indefinite

RR - INT
Erosion-Streamflow
Great Basin

Project: A study of the influence of plant cover, as modified by grazing, on water yield and erosion, on watershed lands in the Great Basin.

Modification of the plant cover by grazing and other agencies in recent years has resulted in the depletion of desirable range forage and accelerated erosion on the high summer ranges of the Wasatch Plateau, disastrous floods from the steep slopes of the Wasatch front, and accelerated wind erosion on the floors and foothills of the desert valleys. A full understanding of the natural relationships between the plant cover and run-off and soil erosion is vitally important as a basis for the intelligent protection, management and use of these lands. The project is divided into three subprojects as follows:

Subproject 1

Character and Scope: To determine, on lands typical of the Wasatch Plateau having limestone-clay-shale soil (1) the role of herbaceous vegetation in the regulation of surficial run-off and control of erosion, and (2) the regulation of grazing necessary to maintain adequate cover for watershed protection. The study involves the measurement of cover, soil, slope, precipitation, run-off and erosion on two watersheds of about 10 acres each, the density of the vegetation of which is maintained at a given amount by controlled grazing, and on six permanent run-off plots supporting typical associations of range species.

Progress: Started in 1915 and continued to 1934 under one system of grazing, treatment of the erosion areas A and B has been reversed to check the results of early studies, as published in U.S.D.A. Technical Bulletin 220.

Surface run-off has been measured for two years on the plots established in 1934.

Plans: Records are to be continued on the erosion areas and run-off plots with some refinement of instrumentation to improve the accuracy of results. Funds permitting, surficial run-off will be measured on typical sites by means of portable apparatus.

Assignment: George W. Craddock and A. R. Croft

## Subproject 2

Character and Scope: To determine, on lands typical of the Wasatch front having steep brush covered slopes and soils of granite-quartzite-schist origin, the role of vegetation as affected by grazing in the regulation of water yield and control of erosion, and to develop methods for controlling run-off and floods from torrential summer storms and melting snow. The study necessarily involves the isolation and measurement of all the factors that influence water yield and time and rate of stream discharge, such as climate, soil, plant cover including cultural treatment, and erosion control measures.

Progress: The Davis County watershed, consisting of 18,560 acres of steep mountainous land on the Wasatch Forest and directly tributary to 5,120 acres of highly developed valley land, was selected as an experimental area for these studies in 1933. The area has been made accessible by road and temporary quarters have been erected for housing field personnel.

The area has been mapped and inventoried with respect to topography, plant cover and soil, revealing a very high correlation between accelerated erosion and depleted plant cover.

A terrace-trench system of erosion control, involving artificial reseeding and planting, was developed and applied to about 400 acres. This much work was sufficient to control erosion on five of the six canyons comprising the study area. Barrier type flood control structures were installed at the mouths of each canyon.

Twelve 1/40-acre and four 1/10-acre run-off plots have been installed to measure surficial run-off and erosion on a yearlong basis and seven large experimental watersheds have been selected to determine the effectiveness of erosion control methods for regulating run-off and controlling erosion under different intensities of grazing. Stream gaging installations have been installed on three of the watersheds.

An improved stream gaging structure has been developed for measuring debris-laden water on steep slopes, and equipment purchased for water cycle studies.

Plans: To continue records of climate and run-off on plot areas. To complete range and soil inventories, and the construction of additional erosion control works, and roads. To locate and equip run-off areas and comparable watersheds with suitable devices for measuring

run-off and erosion. To continue studies of the value of water from the watershed, physiographic factors affecting soil formation and erosion, and mudflow histories.

A second phase of this project involves the initiation of run-off and erosion studies on small experimental watersheds situated near Salt Lake City, as a basis for developing satisfactory erosion control methods for foothill lands of the Wasatch front. Plans have been completed for proceeding with this work in cooperation with the Wasatch Forest.

Assignment: Bailey, Craddock, Croft, _____

Date of Completion: Indefinite

RS - INT
Mc-Ponderosa Pine

## FOREST MANAGEMENT (SILVICAL RESEARCH)

Project: Methods of cutting and natural reproduction of ponderosa pine.

Character and Scope: To determine the most satisfactory methods of cutting ponderosa pine to insure satisfactory reserve stands yielding maximum growth and quality products, to insure satisfactory regeneration, to provide for the maximum yields of usable water, and to perpetuate the lumber industry on a sustained and thoroughly sound economic basis. To accomplish this purpose requires thorough investigation of past practices, both on privately and publicly owned lands, detailed knowledge of the all attendant conditions affecting tree growth and reproduction, and investigation and actual field application of such new woods practices as developed either locally or in other regions.

Progress in 1935: Attention was focused in 1935 on natural reproduction aspects of the problem. Reproduction occurring in virgin stands, on cut-over areas and burned areas was studied. Preliminary results advance many interesting and valuable implications, some of these being that seeding beyond 100 feet from the parent trees is neglible; that within the 100-foot zone of seeding survival decreases as the seed tree is approached; that in spite of an unusually good seed crop in 1934 only an average of 16 ponderosa pine seedlings per acre in the virgin stand, and 20 ponderosa pine seedlings per acre in the cut-over stands survived the first year; that drought was the major cause of mortality; that a great many more seedlings per acre survived the first year on a recent burn than on unburned areas, due probably to a great degree to lack of root competition on the former; and that regeneration of burns should be concentrated upon the year immediately following the fire. Many other significant trends were observed and will be followed up by subsequent study.

A rodent and a stockproof enclosure were established on each of south slope, north slope and flat. Within these exclosures a series of seed beds were sown to provide a means of studying various factors influencing survival and germination. Studies of seed production and cone and flower development were begun also.

The cut-over cruise information which has been collected since 1932 is in the process of compilation and is yielding remarkable comparative data for the various cut-over areas in Region 4 as a whole. The method of cutting plots, established on the experimental forest, were checked for reproduction and cone production.

Plans: Emphasis will be placed on the natural reproduction as in 1935. Analysis of cut-over data will be hastened in an effort to close this phase of the project. Methods of cutting and reproduction plots on the Salmon and Payette National Forests will be remeasured and reexamined. Continued effort will be expended to develop the experimental forest with utilization roads so that management will be feasible as soon as surrounding conditions permit.

Assignment: _____ and E. L. Mowat

Date of Completion: Indefinite

RS - INT
Mc-Ponderosa Pine

Subproject: Fire damage and fire-hazard determination for central Idaho Forests.

Character and Scope: To continue the burned-over area investigations in regard to rate and success of both natural and artificial regeneration; to determine succession of lesser vegetation on fire areas; and in cooperation with the Regional Office, to collect and analyze fire weather data.

Progress in 1935: Two reports on this subproject were published in 1935; plots and transects on the study areas were reexamined and certain fire weather data were collected and analyzed.

Plans: The studies under way will be continued and more active cooperation will be both received from and extended to the Regional Office, particularly in compilation and analysis. A study of the increase or decrease of lesser vegetation under fire protection as it is ultimately reflected on fire hazard was proposed for 1935, but lack of time and funds caused its elimination. If possible, this study will be made during the coming year.

Assignment: E. L. Mowat

Date of Completion: Indefinite

RS - INT
Mc-Ponderosa Pine

Subproject: Ponderosa pine root systems.

Character and Scope: To determine the morphology of ponderosa pine roots as an aide in reproduction studies, planting studies, and method of cutting and timber improvement investigation.

Progress in 1935: A series of 1-, 2-, and 3-year old ponderosa pine seedlings were dug and their roots studied carefully. Average depth of roots was 22, 30 and 50 inches for 1-, 2-, and 3-year old seedlings, respectively. The marked contrast observed between root systems on different sites and great contrast between roots of natural seedlings and planting stock illustrated vividly why such distinct differences in survival have been observed. A nursery was developed as an aid in attempting to perfect root systems of local planting stock which will more nearly approach those natural seedlings.

Plans: On the basis of the 1935 work a detailed work plan for this study will be prepared and as rapidly as available time and funds permit the study will be continued.

Assignment: _____ and E. L. Mowat

Date of Completion: 1938

RS - INT
Mc-Ponderosa Pine

Subproject: Timber stand improvement.

Character and Scope: To evolve and put into practice for study of growth and for demonstrational purpose, methods of timber stand improvement which are silviculturally and economically feasible in the ponderosa pine type.

Progress in 1935: The timber-stand improvement areas established in 1934 were put in final shape and the plots examined for snow breakage. In regard to the latter, no trees larger than 5 inches D.B.H. were injured by snow, the injury increasing with decreased D.B.H. until the loss reached 12 to 15 percent in 1- and 2-inch D.B.H. classes. One additional area in a 60-70 year stand was developed for investigative and demonstration purposes.

Plans: Should emergency labor be available additional timber stand improvement work on the experiment forest is planned. Special emphasis in this type of work will be placed on the economic advisability of pruning in young growth of 60 to 70 years of age. A study dealing with this subject is contemplated.

Assignment: _____ and E. L. Mowat

Date of Completion: 1937 except for plot observations

RS - INT
Mc-Ponderosa Pine

Subproject: Tree physiology.

Character and Scope: To determine whether desiccation of green foliage throughout the summer is related to increase in fire hazard, and if so, to what extent.

Progress in 1935: The study inaugurated in 1934 was continued throughout 1935. The results obtained in 1935 verified those obtained in the previous year. In general, major points brought out by this study were as follows:

1. The volatile content, largely moisture, of 2-, and 3-year old ponderosa pine was highest in late summer rising from a low in early spring and decreasing from the late summer peak as autumn approached.

2. Site, position of the needle on the tree, date sample was taken and the individual tree itself all caused significant variations in the volatile content of the needles.

3. Ceanothus leaves became progressively more desiccated as the season progressed.

4. One-year old pine needles acted much the same as Ceanothus leaves.

In connection with this study the nutrient content of the needles was analyzed.

Plans: It is contemplated to close this study until it can be approached more intensively at some later date. A report will be prepared for publication on the progress thus far at an early date.

Assignment: _____

Date of Completion: 1936

RR - INT
Management
Summer Range (Wasatch Plateau)

## RANGE MANAGEMENT INVESTIGATIONS

### SUMMER RANGE (WASATCH PLATEAU)

Project: The development of methods of range management of high mountain summer range lands to insure the maintenance and improvement of the grazing capacity of the native forage crop in a manner best to meet the requirements of the range itself, of the dependent livestock, and of the related forest land resources.

Character and Scope: This broad project logically breaks down into a number of subprojects, of which the following are under study at the present time.

1. The effect of climate on plant growth.

2. Vegetational readiness and the length of the grazing season on summer range.

3. Natural revegetation as a means of improvement and maintenance of the range.

4. The degree of utilization as a factor in range management.

5. The influence of season, frequency and degree of harvesting on the productivity, revegetation and vigor of range vegetation.

6. The determination of the influence of rodents on summer range lands with a view of exercising control for the improvement of the range.

RR - INT
Management
Summer Range (Wasatch Plateau)
(Climate and Plant Growth)

Subproject: The effect of climate on plant growth.

Character and Scope: To determine for the three major elevational and forage type zones of the mountain summer range (1) which of the climatic factors are of primary importance to forage growth; (2) the part climate, and particularly the fluctuations in climate from year to year, play in (a) forage development and production, (b) the outcome of experimental work generally; and (3) the adjustments in range management necessary to meet fluctuations in forage production.

Progress Made: Records of the more important climatic factors have been kept during the main growing season continuously since 1914, and in some instances yearlong, in three vegetational (altitudinal) zones on the Wasatch Plateau in Utah. These data have been completed in manuscript form and are to be submitted for publication. Forage yield and time and rate of growth have been observed since 1924 to correlate plant growth and forage yield with the climatic factors.

Vicissitudes of climate as they affect both the time and length of grazing season and the quantity of forage produced have long been recognized to play an important role in range management and forage production. Nevertheless, other exigencies have lead to practices of making both range management and livestock handling conform more or less to set calendars of operation. Results to date in this study by measuring the extent of these fluctuations and their influence on time, rate and quantity of forage production show that variations in climate are so wide as to appear to justify certain elasticity in range management plans or some other provisions to meet them. Total forage production for a season, for example, may vary from as much as 120 percent above the average in one year to 77 percent below the average in another year. Also the time when grazing should begin may vary as much as 47 days earlier in one year as compared to other years.

Plans: The project will be continued along the line of developing facts and information upon which to base range use that will more adequately meet this problem of climatic vicissitudes from the standpoint of the needs both of management of the range and the needs of livestock. Any study involving climate necessarily must be on a long time basis because of the naturally wide variety of conditions to be met. Climatic records also perforce must be continued in order to be able to weigh the influence of climate in the outcome of other experimental studies.

Assignment: Raymond Price

Date of Completion: Indefinite

RR - INT
Management
Summer Range (Wasatch Plateau)

Subproject: Vegetational readiness and the length of the grazing season on summer range.

Character and Scope: To determine the time at which livestock may be admitted to the range without injury to the forage from too early use, (2) methods of determining the time of range readiness, (3) the time that grazing should be discontinued in the fall, and (4) the effects of continued early and late use on the vigor and production of range forage plants.

Progress Made: The results obtained prior to 1923 were published in Department Bulletin 1405.

Phenological observations have been made from 1925 to 1932 of the important range plants at varying elevations from year to year. Detailed growth records of individual plants of important forage species have been obtained from the start of growth in the early spring and continuing throughout the season until covered with snow in the fall.

These data have been completed in manuscript form and are ready for publication.

Plans: Phenological observations will be continued.

Assignment: Raymond Price

Date of Completion: Indefinite

RR - INT
Management
Summer Range (Wasatch Plateau)

Subproject: Range improvement and maintenance by natural revegetation of native forage species on summer range lands.

Character and Scope: To determine (1) the most expedient and economical method of natural revegetation of native forage plants, (2) the rate of reestablishment of valuable forage plants on depleted range lands, (3) the role of seed production and germination as a factor in the natural revegetation of range lands, and (4) methods of management of livestock on the range to meet the requirements of the native forage plants for natural revegetation and at the same time meet the feed requirements of the livestock to the fullest degree possible.

Progress Made: Seventy-six quadrats, 71 major plots, and 7 intensively mapped areas have been established since 1914 in the three major vegetational zones on the Wasatch Plateau in central Utah. These plots have been remapped and rechecked at definite intervals to determine the change of the native forage cover on range lands varying in degrees of depletion, erosion and intensity of grazing. Results to 1922 have been published in Departmental Bulletins 791 and 1405.

All of the data obtained up to and including 1934 have been compiled and analysis started.

Seeding habits, seed production, seed dissemination and germination under various conditions of storage, temperature, and moisture relationships for 55 important range species have been determined for four seasons. These data have been completed in manuscript form and are ready for publication.

Plans: The plots will be mapped in accordance with the regular schedule. These plots will be continued for an indefinite period. Compilation will be undertaken with a view of preparing a progress report. In addition, an intensive vegetation survey will be made of Ephraim Canyon to furnish additional information.

Assignment: Raymond Price

Date of Completion: Indefinite

RR - INT
Management
Summer Range (Wasatch Plateau)
(Season, Frequency and Degree of Harvesting)

Subproject: The relation of season, frequency and degree of harvesting to the productivity, revegetation and vigor of the vegetation.

Character and Scope: To determine (1) the effect of harvesting at different seasons, intervals and closeness of cropping upon the vigor revegetation and productivity and carbohydrate accumulation of important forage species growing on mountain summer range and (2) to work out methods of grazing based on the results to improve and maintain the range, and at the same time obtain the best use of the forage.

Progress Made: The main results of early work, involving 11 species and 20 methods of harvesting, are reported on in Department Bulletin 1405. The project was revised in 1923 to study more critically some of the methods previously tried out, on a plot rather than individual plant basis, supplemented with actual grazing trials. A progress report of the herbaceous clipping has been completed. Partial reports have been completed for the grazing phase and browse clipping. Field work of the carbohydrate study has been completed and a manuscript on the food march phase has been completed and submitted for publication.

Plans: To continue the analysis of all available data in the empirical phase and to complete a final report of the clipping phase of the carbohydrate study.

Assignment: Raymond Price. (Carbohydrate study in cooperation with Dr. E. C. McCarty of Riverside College.)

Probable date of Completion: Present phases will be completed in 1936.

RR - INT
Management
Summer Range (Wasatch Plateau)
(Biological Investigations)

Subproject: To determine (1) population, (2) species, (3) habits, (4) forage consumption, and (5) influence on summer range plants of range rodents with a view of maintaining a proper balance to insure greater forage yields.

Progress Made: Four 40 x 40 feet rodent proofed exclosures were constructed in 1931 in the four main vegetative types. Plots have been established inside and outside the exclosures and mapped at regular intervals. No attempt has been made to determine the population, species, habits, and forage consumption of the rodents since the cooperation with the Biological Survey has temporarily ended.

Plans: It is planned to recheck the established plots as scheduled and continue notes on rodent activity.

Cooperation: Biological Survey

Assignment: Raymond Price (Cooperation with Biological Survey)

Date of Completion: Indefinite

RR - INT
Management
Summer Range (Wasatch Plateau)
(Degree of Utilization)

Subproject: The proper degree of utilization of important range plants.

Character and Scope: To determine (1) proper degree of utilization, (2) standards for judging utilization, and (3) percentage of good forage which should remain at time of seed maturity each year on ranges where deferred and rotation grazing is not applied to improve or maintain the forage stand.

Progress Made: A pasture was constructed on the high summer range lands of the Wasatch Plateau in 1923 and has been grazed by a small herd of cattle since 1925. Twelve hurdle plots 16 x 16 feet, supplemented by 12 quadrats were placed in this pasture to secure varying degrees of utilization of the important range plants each year. Field work was discontinued in 1932 on the first phase of the study. All data was compiled and a progress report completed.

Plans: The data on the first phase of the study will be analyzed further with a view of completing a journal article. The second phase will be initiated.

Assignment: Raymond Price

Date of Completion: Present phase will be completed in 1936.
Second phase is indefinite.

RR - INT
Artificial Reseeding

Project: Artificial reseeding of depleted mountain summer range lands.

Character and Scope: To determine (1) suitable species, (2) site conditions, (3) methods and time of seeding, (4) seed production, (5) methods of grazing during periods of establishment, and (6) economics of improving depleted range by introduction of tame (cultivated) and native forage species on mountain ranges in central Utah where the annual precipitation is from 18 to 30 inches, and the growing season 100 to 120 days in length.

Progress Made: Artificial reseeding trials have been undertaken since 1910 on the Wasatch Plateau in Utah. These trials have been on a small scale and of an empirical nature. A large number of forage species have been tried out at different elevations under various soil conditions, moisture, time of seeding and treatment. The results of the work up to 1927 were published in 1931 in Department Circular 178.

Practically all of the artificial reseeding tests made since 1925 have been in the oak brush zone where the main growing season extends from May 1 to August 31. The sweet clovers, crested wheatgrass, common brome, slender wheatgrass and many-flowered brome were used in most of the tests. These tests involved various methods of tilling the land, covering the seed, and time of sowing. These data have been completed in manuscript form and are ready for publication.

Plans: This subproject has been incorporated with the newly established Artificial Reseeding Project. Future work will be in conjunction with the plans for the main study.

RR - INT
Management
Sagebrush-Wheatgrass

Project: The management of sagebrush-wheatgrass range.

Character and Scope: To develop methods of range management which will maintain or improve native forage on sagebrush-wheatgrass ranges and at the same time develop its best use for range sheep and cattle production.

The sagebrush-wheatgrass ranges of the region are in heavy demand for spring-fall grazing, and for the most part are far below potential productivity as a result of the injudicious use of the range. They are key lands to range livestock operations and improved methods of management are required to insure economical operation.

The broad project breaks down into several divisions, three of which are under study at the present time. Under these three major subdivisions are included four subprojects:

I. Climatic Studies

Subproject 1 - Effect of Climate on Forage Production

II. Grazing Studies

Subproject 2 - Rotation of Spring Grazing Use

Subproject 3 - Intensity of Spring Grazing Use

III. Induced Plant Succession

Subproject 4 - Effect of sagebrush removal by burning on the subsequent forage production of sagebrush-wheatgrass range.

Progress Made

U. S. Sheep Experiment Station: Range management studies started at the U. S. Sheep Experiment Station in 1923 in cooperation with the Bureau of Animal Industry. Four significant results have been derived from these past studies: (1) that climate is an important factor in annual variation in forage production; (2) that overgrazing in the spring, regardless of whether early or late, is detrimental; (3) that moderate grazing at a fixed period in the spring is likely to be detrimental; and (4) that a portion of the spring forage growth should be left for fall grazing, since summer and fall growth are too uncertain to be relied upon for fall feed.

Fremont County Burning Study: Studies of sagebrush burning started on Idaho State land leased by Fremont County Woolgrowers Association in 1932 indicate that fires of light intensity will effectively kill sagebrush and have no noticeable effect on soil or vegetation. Heavy burning increases the volume of herbage in wheatgrass (Agropyron dasystachyum) and changes organic content, water-holding capacity, total nitrogen and pH of the soil materially. Moderate intensity burns increase the basal area of grasses especially wheatgrass and junegrass (Koeleria cristata).

Cooperation: U. S. Sheep Experiment Station of the Bureau of Animal Industry, Fremont County Woolgrowers and State of Idaho.

RR - INT
Management
Sagebrush-Wheatgrass

Subproject: Effect of climate on forage production.

Character and Scope: To determine on sagebrush-wheatgrass ranges, (2) which of the more important climatic factors play a part in the variations in forage production, (b) the part that variations in climate play in forage production and development and the adjustments in present grazing practices necessary to meet those fluctuations.

Progress Made: Forage production varies from 60 percent above to 65 percent below normal with two or more successive deficient years occurring. Similar stages of plant development may vary as much as 40 days in subsequent years.

A manuscript is being prepared on the immediate effects of the drought of 1934.

Records of climate are available from 1923 to 1934. Forage yield and plant growth have more or less been closely observed since 1932.

Plans: The subproject will be continued, enlarging the present set-up to include measurements of humidity, evaporation and soil moisture throughout the growing season, with the view of developing facts and conclusions more adequately correlated with fluctuations in forage production.

Assignment: George Stewart, G. D. Pickford

Date of Completion: Indefinite

RR - INT
Management
Sagebrush-Wheatgrass

Subproject: Rotation of grazing use.

Character and Scope: To determine and develop systems of range management that will maintain or improve sagebrush-wheatgrass ranges.

This subproject is divided into two phases: (a) experimental tests in paddocks and (b) practical tests on a range basis.

Progress Made: Experimental tests in paddocks were started in 1933. Two series of four 80-acre paddocks were set aside for the study of rotation and rotation-deferred grazing systems, one series being devoted to each system.

Using the results from the 1934 range survey, the 23,000-acre range has been tentatively divided into four allotments. Each allotment is divided into units. On these four allotments rotation and deferred grazing systems are to be tested out on a practical basis.

Plans: Experimental tests in paddocks will be continued and an attempt will be made to initiate the practical studies on a range basis.

Assignment: George Stewart and G. D. Pickford with __ __ Smith of the U.S.S.E.S., Bureau of Animal Industry

Date of Completion: Indefinite

RR - INT
Management
Sagebrush-Wheatgrass

Subproject: Intensity of spring grazing use.

Character and Scope: To determine the proper degree of spring use on sagebrush-wheatgrass ranges.

Progress Made: Six 80-acre paddocks are set aside for the study of intensity of spring grazing. Six intensities of use will be tested on these paddocks, namely, 6, 8, 10, 12, 14, and 16 sheep-days per acre. It will first be necessary to secure relative carrying capacities on four new paddocks included in the set-up in order to properly apply the grazing intensities.

Plans: Intensity studies will be initiated until 1936.

Assignment: George Stewart, G. D. Pickford

Date of Completion: Indefinite

RR - INT
Management
Sagebrush-Wheatgrass

Subproject: Effect of sagebrush removal by burning on the subsequent forage production of sagebrush-wheatgrass range.

Character and Scope: To determine, on sagebrush-wheatgrass range where sagebrush is not a true dominant, the efficiency of controlled burning in removing the sagebrush and the effect on the soil, vegetation and subsequent forage production.

Progress Made: All intensities of burning were successful in exterminating the sagebrush. Only burns of high intensity showed deteriorating effects on the soil. Basal areas of wheatgrass and of all grass plants occurring on 56 quadrats increased in burns of moderate intensity. Density of wheatgrass increased in direct ratio with intensity of burn, some grasses especially stipas and fescues were injured by fire.

A manuscript is in preparation giving in detail the effects of controlled burning on the vegetation of sagebrush-wheatgrass range.

Plans: During 1936 the experimental area will be moderately grazed to study the behavior of the burned range under conservative use. Soil moisture studies and phenological studies will be made in comparable sites on burned and unburned range to determine, if possible, the site difference occurring as the result of the use of fire.

Assignment: George Stewart, G. D. Pickford

Date of Completion: Indefinite

RR - INT
Management
Desert Shrub Range

Project: Management of desert shrub ranges.

Character and Scope: To determine range management methods which will restore and maintain the grazing productivity and promote the best use of desert shrub ranges. This involves knowledge of the character, distribution, palatability, forage value, growth requirements, and reaction to grazing of the native vegetation.

Progress Made: Investigations were started in 1930 and carried through 1935. These show a 58 percent reduction in the grazing capacity of the desert shrub ranges, many of the better forage species being replaced by inferior forage plants. Drought during the last 4 years has resulted in severe mortality of many desert plants and when augmented with injudicious grazing the loss of the more palatable species is sometimes enormous. On heavily grazed ranges 89 percent mortality in Oryzopsis hymenoides and 67 percent in Eurotia lanata have occurred. Drought not only results in heavy mortality but reduces greatly the current plant growth. So complete was the drought in 1934 that growth was less than 20 percent of normal. To determine the extent of these factors and their influence upon grazing capacity, plant succession, forage production, and the possibilities of rehabilitating either naturally or artificially the declining desert shrub ranges is essential and basic in developing proper methods of range management.

A complete range survey of 55,000 acres included within the desert range experimental area and 15,000 acres of adjacent range land has been completed to serve as a basis for comparing influences of future grazing. Soil surveys and vegetative transects were made to show the trend of plant succession in relation to grazing, climate, and soil. Studies of plant development, palatability, nutritive value of desert vegetation are being conducted. A detailed comparison has been made between the fenced, protected desert shrub ranges and those open to unrestricted grazing to determine the innate forage possibilities and the influence grazing has exerted on the destruction and depletion of the ranges. Quadrat and detail study plots have been established on the experimental range to serve as a basis of future study.

The major part of the physical development of the Desert Range Branch headquarters has been completed together with the establishment of fenced plots and pastures where controlled and intensive range studies are being made.

A large part of the data collected thus far has been analyzed and manuscripts prepared for several of the studies.

Plans: Analyze and prepare manuscripts on all completed projects and prepare progress reports on all partially completed projects. Concentrate and develop detailed and intensive experimental work at the Desert Range Branch headquarters to study ecological factors affecting plant succession, influence of seasonal and various intensities of grazing use on desert shrub range, natural rehabilitation, influence of climate on plant growth, palatability and utilization, nutritive value of native forage species, value of supplemental feed, and development of suitable methods of range management.

Assignment: George Stewart, Selar S. Hutchings.

RR - INT
Management
Artificial Reseeding

Project: Artificial reseeding.

Character and Scope: To determine the quality of soils on sites where reseeding is required to bring about revegetation of depleted areas and to speed up revegetation of watersheds and other areas of critical importance; to determine the forage species, whether native, imported or produced by plant-breeding that are best adapted to the various soil types; and to determine the most suitable time and methods of seeding and of subsequent treatment of reseeded areas to obtain the most satisfactory revegetation.

Progress Made: Investigations have just begun but it has been shown that the better forage grasses can thrive only on fairly good soils, and that the soils vary widely in their quality. It has already been demonstrated that cheap seeding methods are necessary, and that new sources of seed supply must be developed to keep the cost down.

Cooperative agreements with the Bureau of Plant Industry and the Utah State Agricultural College have been completed and signed by the respective chiefs. General plans of investigation have been made, ready for detailed plans to be filled in as the work centers are selected and their possibilities studied.

Plans: The immediate plans are: (1) to develop the details of the outline plan already made and (2) to prosecute investigations regarding the quality and condition of range soils in need of reseeding; (3) to determine the soil, the moisture, the seasonal, and the altitudinal adaptations of common forage species; (4) to search for better plant varieties by selection from native species, by importation, and by plant-breeding; (5) to test the effectiveness and economy of various times and methods of seeding; (6) to study germination reactions and peculiarities of forage species and to develop sources of seed supply; and (7) to select and develop trial centers for conducting reseeding experiments. Tentatively the following trial centers are being considered.

1. In Ephraim Canyon, near the Great Basin Branch Station (Utah)
2. In Davis-Salt Lake watershed, near the Wasatch Branch Station (Utah)
3. At Desert Range Branch Station (Utah)
4. At U. S. Sheep Experiment Station, Dubois (Idaho)
5. On lower edge of Boise Forest (Idaho). (To be selected.)
6. On lower edge of Humboldt Forest (Nevada). (To be selected.)
7. On lower edge of Wyoming Forest (Wyoming). (To be selected.)

Cooperation: Bureau of Plant Industry on plant breeding, plant physiology, nursery and other related phases of the project; Utah State Agricultural Experiment Station on nursery and breeding phases.

Assignment: Dr. George Stewart and Dr. R. H. Walker

Probable date of completion: Indefinite